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Report No. 8675

PROJECT COMPLETION REPORT

KOREA

SECOND WATER SUPPLY PROJECT
(LOAN 2350-KO

MAY 25, 1990

Infrastructure Operations Division
Country Department II
Asia Regional Office

CURRENCY EQUIVALENTS

Currency unit	= Won (W)
US$1.00	= W 780 (September 1983)
	= W 806 (1984 average)
	= W 870 (1985 average)
	= W 881 (1986 average)
	= W 823 (1987 average)
	= W 720 (1988 average)

WEIGHTS AND MEASURES

meter (m)	=	3.28 feet
kilometer (km)	=	0.62 miles
square kilometer (sq km)	=	0.39 square miles
hectare (ha)	=	10,000 square meters or 2.47 acres
cubic meter (cu m)	=	264 U.S. gallons
cubic meter per second (cu m/s)	=	22.82 million U.S. gallons per day
Gigawatt hour (GWh)	=	1 million kilowatt hours
liter (l)	=	0.26 U.S. gallons
liters per capita per day (lpcd)	=	0.26 U.S. gallons per capita per day

PRINCIPAL ACRONYMS USED

EIA	-	Environmental Impact Assessment
ISWACO	-	Industrial Sites and Water Resources Corporation
KOWACO	-	Korea Water Resources Corporation
MOC	-	Ministry of Construction
MOHA	-	Ministry of Home Affairs
NEPA	-	National Environment Preservation Area
NESPA	-	National Ecological System Protection Area
NWIP	-	National Water Improvement Program
OOE	-	Office of the Environment (in the Ministry of Health and Social Affairs)
PCR	-	Project Completion Report

THE WORLD BANK
Washington, D.C. 20433
U.S.A.

Office of Director-General
Operations Evaluation

May 25, 1990

MEMORANDUM TO THE EXECUTIVE DIRECTORS AND THE PRESIDENT

SUBJECT: Project Completion Report on Korea
Second Water Supply Project (Loan 2350-KO)

Attached, for information, is a copy of a report entitled "Project Completion Report on Korea - Second Water Supply Project (Loan 2350-KO)" prepared by the Asia Regional Office with part II of the report contributed by the Borrower. No audit of this project has been made by the Operations Evaluation Department at this time.

Attachment

KOREA

SECOND WATER SUPPLY PROJECT (LOAN 2350-KO)

PROJECT COMPLETION REPORT

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KOREA

SECOND WATER SUPPLY PROJECT (LOAN 2350-KO)

PROJECT COMPLETION REPORT

Preface

This is the Project Completion Report (PCR) for the Korea Second Water Supply Project (Nakdong Barrage), for which Loan 2350-KO in the amount of US$78.5 million was approved on October 18, 1983. The loan was closed on June 30, 1989 as planned. Due to savings resulting from a decrease in the exchange rate of the won (from 780 per US dollar in 1983 to about 880 by 1986), better self-financing capacity of the implementing agency and lower than expected bids for equipment and consultant services, only about 65% of the original loan was disbursed and US$27.2 million of the loan amount was cancelled in stages throughout the project period. The last disbursement was on March 23, 1989.

The PCR was jointly prepared by the Infrastructure Operations Division of the Asia Regional Office (Preface, Evaluation Summary, Parts I and III), and the Korea Water Resources Corporation, the main implementing agency (Part II). Part II discusses the barrage construction component (comprising 98% of the total project cost of US$217.7 million). Leak detection and institutional development programs implemented under the project by the Ministry of Home Affairs (2% of the project cost) are covered only in Part I.

Preparation of this PCR was started during the Bank's project supervision mission in February 1989, and is based, inter alia, on the Staff Appraisal Report, the Loan and Project Agreements, supervision reports, correspondence between the Bank and the Borrower, and internal Bank memoranda.

KOREA

SECOND WATER SUPPLY PROJECT (LOAN 2350-KO)

PROJECT COMPLETION REPORT

Evaluation Summary

i. Objectives. In line with government objectives under the Fifth Development Plan (1982-86), the project was intended to improve the quality and availability of water supply in the important Nakdong River Basin, which contained one third of the country's total population. Water shortages had become a critical problem basin-wide. Furthermore, despite the construction of dams to even out river discharges through the year, increasing demands on the river had decreased the flow of fresh water in the river's delta, resulting in increased sea water intrusion into the river and high salinity as far as 40 km upstream. The salinity seriously affected the water intake at Pusan, the second largest city in Korea, and required flushing of the delta area with river water, which was urgently needed for agricultural purposes and for some 40 upstream municipalities and large cities.

ii. The project was designed to: (a) eliminate sea water intrusion in the Nakdong delta through construction of a 510 m barrage; (b) make available to Pusan and the neighboring area about 25 cu m/s of water formerly released from upstream dams to prevent seawater intrusion into the river; (c) implement an improved leak detection and control program in some 15 cities; (d) computerize accounting and management information systems in about 15 Water Bureaus; (e) encourage improved financial and water pricing policies in the Korea Water Resources Development Corporation (KOWACO),[1] the main implementing agency, through loan conditionality; and (f) protect the Nakdong's estuarine environment and develop KOWACO's environmental management expertise. Pusan, which would receive about half the water made available by the barrage, also agreed to use its own resources as well as bilateral and commercial financing to expand its water supply system and construct an interceptor sewer/water treatment plant to divert industrial/domestic wastes to downstream of the barrage, preventing contamination of the barrage reservoir which is located downstream of the city's water intakes.

iii. Implementation Experience. The project was completed on time, successfully achieving or surpassing all of its objectives. The barrage was commissioned ahead of schedule in September 1987, a record time (four years) for construction of a major and complex hydraulic structure. The institutional and leakage control programs surpassed their targets, and the complementary Pusan waterworks were also completed ahead of schedule. Sale of reclaimed land will be completed in 1990, and will be sold fully developed (rather than undeveloped as originally planned). Establishment of a Natural Environment Preservation Area (NEPA) to protect an important migratory bird habitat in the Nakdong estuary was a major achievement of the project. Gaining approval of the NEPA was difficult, due to unforeseen objections raised by Pusan City, the time needed to complete

[1] Then called the Industrial Sites and Water Resources Corporation.

required studies and the lengthy process of gaining the required approvals of ten ministries or government/city agencies. Although approval of the NEPA was postponed for three years, until December 31, 1988, moratoria on development and construction during this period provided the area with the same environmental protection as the NEPA. An interceptor sewer to be constructed by Pusan City parallel to the barrage was not included in project financing. When the City encountered serious financial problems due to the accelerated construction of a subway, construction of the interceptor was delayed three years but will be completed in 1990. To compensate for the lack of the interceptor, the operation of the barrage was modified to provide additional flushing during low tides. As originally planned, the loan was closed on June 30, 1989.

iv. Results. All project benefits were achieved. Water salinity in the lower reaches of the river was eliminated, and the water available for municipal, industrial and agricultural use has increased as planned. Without the barrage, water would have had to be rationed in 1988-89. The computerized accounting, billing and management information system has been successfully adopted by almost four times as many Water Bureaus (WBs) as planned. The leak detection program transferred this technology to the WBs and local consultants and provided training, manuals and improved specifications for pipelines and house connections. These benefits were also extended to more cities than forecasted, and the creation and equipping of leak detection units ensured that the benefits would continue. KOWACO's financial performance, although generally satisfactory, deteriorated in 1988, when one of the worst droughts of the century reduced water flows and thus power sales, causing the rate of return on KOWACO's water and dams operations to decline to 2-3%, rather than the 5% covenanted under the Loan Agreement. However, rates of return are expected to be satisfactory by the early 1990s, as water flows (and power sales) return to normal levels. The project was particularly important as a vehicle for environmental action. As agreed under the loan, a 34.2 sq km area of mud flats, islands and wetlands in the Nakdong estuary was declared a NEPA by MOC and a Natural Ecological System Preservation Area (NESPA) by the Office of the Environment, thus giving it maximum legal protection from development and creating a precedent for the protection of other key environmental resources in Korea. Other environmental control measures are also being enforced in the area surrounding the NEPA to further protect the bird habitat. At completion, the project cost was about US$218 million, 31% higher than expected due mainly to the inclusion of additional works, the decision to develop the reclaimed land rather than selling it undeveloped, and increased land compensation costs. Even with the increase in project cost, the rate of return on the project was very high (20%) and similar to the original appraisal estimate of 24%.

v. Sustainability. The project's achievements are expected to be fully sustainable. Barrage inspection and maintenance manuals prepared under the project should ensure optimal operation of the facility. The permanent leak detection units created in the WBs as well as the Environmental Unit and the Environmental Research Division established in KOWACO to monitor the quality of Nakdong water ensure that efforts to reduce leakage and to protect the environment will continue in the future. Leakage control and environmental protection activities will also be expanded nationwide during 1990-95 by a National Water Improvement Program (NWIP), which will expand the leak detection efforts to all cities, replace about 27,500 km of corroded/leaking pipes,

modernize/rehabilitate 20% of the country's water treatment plants, relocate about 550 industries nationwide before 1992 and significantly expand sewage treatment works. The improvement in KOWACO's financial performance achieved under the project, partly through increased water tariffs, should benefit from the 30% increase in water tariffs during 1990-92 approved by the President in conjunction with the NWIP. Because of KOWACO's institutional success, the Government may give KOWACO overall responsibility for management of water quantity, quality and sewage treatment on the main rivers, including the Nakdong. This should help to further improve environmental conditions throughout entire basin areas.

vi. Findings and Lessons Learned. KOWACO's excellent technical capabilities and experience allowed it to complete construction of the large and complex hydraulic structure in record time (less than four years). And, although the project's environmental targets were probably too ambitious -- minimizing the environmental damage from barrage construction and, more ambitiously, ensuring full ecological protection to the bird habitat in the Nakdong estuary -- they were nonetheless successfully achieved. The lessons learned under the project were: (a) the advanced state of project preparation and the procurement of project civil works under a single contract greatly reduced the cost of the barrage (to about 60% of the initial engineering estimate), simplified project implementation and shortened the construction period; (b) environmental protection requiring changes in laws or regulations is difficult and requires a long lead time to gain consensus on issues that affect a number of government agencies with varying interests and objectives; (c) technology transfer, particularly for accounting and leak detection, can be carried out successfully in a large number of cities at minimum cost; and (d) loan covenants which are realistic and achievable result in compliance.

PROJECT COMPLETION REPORT

KOREA
SECOND WATER SUPPLY PROJECT
(LOAN 2350-KO)

PART I: Bank Review of the Project

Project Identity

- Project Name: Second Water Supply Project (Nakdong Barrage)
- Loan Number: 2350-KO
- RVP Unit: Asia
- Country: Korea
- Sector: Water Supply and Sewerage
- Subsector: Water Supply/Environmental Protection

Background

1. Under its Fifth Development Plan (1982-86), the Government of Korea proposed to almost triple investment in the water supply and sewerage sector compared to the Fourth Plan. Its goals were to preserve water quality, replace obsolete equipment and pipelines, invest in sewerage and sewage treatment, and expand the capacity and coverage of the country's water supply systems. The Plan also acknowledged the need to address the environmental deterioration that had accompanied the country's accelerated industrial and urban growth.

2. The Second Water Supply Project reflected these goals as it was designed to improve the quality and availability of water supply in the Nakdong River Basin which contained one third of the entire population, producing 30% of total agricultural and 40% of industrial output. Both Pusan and Daegu, Korea's second and third largest cities, are served by the Nakdong. At the time, water shortages had become a critical problem in the river basin, where about two thirds of total annual rainfall occurs from July to September. Although a major dam had been constructed 340 km from the river mouth to even out river discharges through the year, the increasing demand on the river from the 37 municipalities it served decreased the flow of fresh water in the river s delta, particularly from January to June. As a result, sea water intruded almost 40 km upstream, causing high salinity levels at the intakes for Pusan and Ulsan/Onsan, which frequently had to stop pumping, and damaging the land in the important Gimhae agricultural polder area, due to irrigation with the highly saline water.

3. Bank support for construction of the barrage and further development of sector institutions, as provided under Loan 2350-KO, was fully in agreement with Bank's sector objectives in Korea of promoting reliable, affordable water and sanitation services, helping to strengthen sector institutions and their coordination, and developing the sector's financial basis. This was the second project in the water supply sector. The First Water Supply Project (Loan 2072-KO) initiated the Bank's focus on service in the urban areas by expanding the water supply in five cities--Daegu, Gwangju, Masan, Changweon and Jinhae-- and was successfully completed in 1986. Bank loans to Korea for urban water supply development are listed in Part III, Table 1.

Objectives and Description

4. The objectives of the project were to: (a) eliminate problems associated with sea water intrusion in the Nakdong delta; (b) make available to Pusan and another 12 cities, 24 towns and industrial zones, about 25 cu m/s of water released from upstream dams to prevent seawater intrusion into the river

(enough to supply 10 million people with 200 lpcd); (c) transfer leak detection and control technology and implement such programs in some 15 cities; (d) establish computerized accounting and management information systems in about 15 Water Bureaus; (e) improve the financial and water pricing policies in the Korea Water Resources Development Corporation (KOWACO),[2] the main implementing agency; and (f) protect the Nakdong's estuarine environment and develop KOWACO's environmental management expertise.

5. The project had three components:

(a) Construction of the Nakdong Barrage (500 m long), including appurtenant works, dikes, dredging, land reclamation of 190 ha, a discharge sluice, a navigation lock, fish passes, a four-lane road, and service and operation facilities. The project also provided for systematic monitoring of the estuarine environment, quantitative and qualitative ecological impact studies, and the preparation and implementation of an environmental protection program by KOWACO; laboratory equipment was provided for the studies and microcomputer hardware for environmental management;

(b) Leak Detection Program, to reduce non-revenue water which often accounted for more than 30% of water produced. Equipment and training were provided to implement newly-introduced methodologies to detect and correct water leakage in about 15 cities, with nationwide replication of the program expected; and

(c) Institutional Development Program, comprising the provision of microcomputers to about 15 city Water Bureaus and development of standard programs for billing, accounting, payroll, inventory management, etc. to strengthen their accounting, financial and managerial capabilities, with the expectation of eventual nationwide dissemination of the program.

6. Pusan, a principal beneficiary of the project, agreed to carry out and self-finance a variety of water and sewerage works to complement barrage construction. Pusan was to receive about half the water made available by the barrage, be relieved of water rationing and salinity problems, and provided with a new road over the barrage as well as 190 ha (later expanded to 330 ha) of reclaimed land for industrial and residential use. The complementary works included construction of (a) a new treatment plant and distribution system for 500,000 tons of water per day and (b) the Janglim interceptor sewer to divert industrial and domestic wastes to downstream of the barrage, thus preventing contamination of the barrage reservoir which was some 20 km downstream of the city's water intakes. The cost of the Pusan works would be about US$130 million, with financing provided by the city and a US$25 million loan from the Overseas Economic Cooperation Fund of Japan.

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[2] Then called the Industrial Sites and Water Resources Corporation (ISWACO).

Design and Organization

7. Plans for barrage construction and project programs were satisfactory. Barrage construction was carried out by KOWACO, a semi-autonomous corporation under the Ministry of Construction (MOC), with responsibility for construction of multipurpose dams and regional water supply systems. The barrage was identified by four different studies as the least-cost solution to prevent salinity intrusion in the delta and provide additional water to downstream cities and towns. The Bank's involvement during the selection of the barrage design, the preparation of which was funded under Loan 1666-KO, was instrumental in ensuring that the location of the barrage was based mainly on environmental considerations. The three initial design alternatives proposed by the 1981 feasibility study were therefore rejected and replaced by a costlier but environmentally-superior alternative. The extensive Environmental Impact Assessment (EIA) for the barrage was reviewed carefully by the Bank and extensively commented upon. The solution finally adopted drastically reduced the land reclamation initially proposed and included many features for environmental protection such as underflow and overflow gates to allow the circulation of nutrients, even under low flows, fish ladders, interception and treatment of sewage flows, and regulation of minimum flows.

8. The Ministry of Home Affairs (MOHA) implemented the two institutional components. The project's programs to improve leakage detection by the Water Bureaus and to introduce a computerized accounting and financial management system addressed major deficiencies in the Water Bureaus' financial and operational practices, indicated by high levels of non-revenue water, the lack of double entry accounting, manual billing, weak management information systems and insufficient staff.

9. Although inclusion in the project of the complementary works in Pusan was considered during project preparation (see Part III, Table 2), the city decided that it did not need Bank financing. However, to ensure cost recovery and timely construction of these works, as a condition of Board presentation, the Mayor of Pusan signed a letter of understanding committing the city to pay KOWACO for the additional water it used and to construct additional water supply works as well as the Janglim sewer interceptor and treatment plant by December 31, 1987. While the waterworks were completed on schedule, the interceptor was delayed. The estimated cost of the interceptor, in 1983 prices, was US$16 million, to be financed 20% by city funds, 60% by foreign and commercial loans and bonds, and 20% by the Central Government. This was not expected to impose a major burden on city finances. However, the city's rapid construction of a large subway system during 1984-89 almost bankrupted city finances and resulted in slow implementation of the interceptor, which will be completed in 1990 rather than 1987 as planned. This delay has required changes in the operating procedures of the barrage during the dry season to flush the reservoir during low tides. The cost of interceptor works was also greatly increased by including a full sewage treatment plant of larger capacity than planned. Pusan's financial problems also initially caused it to delay paying KOWACO for the cost of the additional water received (at the average long-term marginal cost, as KOWACO agreed in Section 4.08 of the Project Agreement). Pusan also came into conflict with the Government over the project's protection of an important migratory bird

habitat downstream of the barrage, which it wanted for industrial development (para. 21).

Implementation

10. The project was completed on schedule, achieving or surpassing all of its objectives. The barrage was commissioned ahead of schedule in September 1987, with construction carried out in only four years, a record for the construction of a major hydraulic structure. The computerization and leakage control programs surpassed their targets. The two programs were completed about two years later than originally planned (but within the original closing date), due to delayed selection of consultants, procurement of additional leak detection equipment and, more important, implementation of the programs in more WBs than expected. The computerization program was originally targeted for 15 cities but was tested in 31 Water Bureaus and eventually implemented in a total of 58 cities. The leak detection program was carried out as expected in 12 cities but was then implemented in another five cities (included under the First Water Supply Project). Initial delays, due to a significant shortage of staff and inadequate government budgetary allocations, were addressed and the component was implemented satisfactorily. Complementary waterworks carried out by Pusan were completed ahead of schedule. Sale of the reclaimed land was delayed to 1989-90 due to a decision to develop the land before sale, rather than leaving it undeveloped as originally planned; this change greatly increased the value of the land. With strong demand for land in the Pusan area, the land reclaimed and developed under the project has been sold as soon as it was available.

11. Establishment of a Natural Environment Preservation Area (NEPA) to protect an important migratory bird habitat in the Nakdong estuary was a major project achievement. Gaining approval of the NEPA was difficult due to unforeseen legal objections raised by Pusan City and the long process of completing required studies and gaining the approvals of the ten ministries and government agencies involved in the NEPA approval process. Although the final NEPA approval was postponed for three years, until December 31, 1988, the construction and development moratoria approved for the area during these years achieved the same environmental protection objectives as the NEPA.

12. Construction of the Janglim interceptor sewer parallel to the barrage was not included in project financing and was largely self-financed by Pusan City. When the City encountered serious financial problems due to accelerated construction of a subway, interceptor construction had to be delayed by three years but is expected to be completed in 1990. To compensate for the lack of the interceptor, the operation of the barrage was modified, allowing for flushing of the reservoir during low tides. As originally planned, the loan was closed on June 30, 1989.

Project Results

13. All project components were carried out successfully. The barrage is operating satisfactorily, eliminating salinity in the downstream areas and allowing water to be used for municipal, industrial and agricultural uses. Demand projections indicate that the incremental water supply will be fully used by 1994. Without the barrage, the drought conditions now prevailing in the Nakdong

area would have forced Pusan and Ulsan to cut off water supply for several hundred hours a year, and would have required large releases of water to reduce salinity intrusion, resulting in water rationing in many upstream cities. The barrage also allowed intensification of agriculture in the Gimhae area and higher productivity. The land reclaimed under the project is expected to be sold for about US$302 million, or about 50% more than the total project cost, and is important for further industrial and residential development in Pusan, which is one of the most densely populated cities in the world.

14. The computerized accounting and management information systems developed under the project have been successfully adopted by more than 50 WBs, about four times the initial target, helping them to operate more efficiently. Under the leak detection component, up-to-date technology was transferred to the WBs and local consultants, and manuals and improved specifications for pipelines and house connections were developed for nationwide use. The benefits of the leak detection program were also extended to more cities than forecasted and, through the establishment and equipping of leak detection units in each project WB, the project ensured that these benefits will continue, to the benefit of operational efficiency and cost recovery.

15. KOWACO's financial performance was generally satisfactory throughout the project but deteriorated in 1988, when one of the worst droughts in this century reduced water flows and thus water and power sales. As a result, the rate of return of KOWACO's Dams Division declined from 9% in 1987 to 3% in 1988, below the covenanted 5% under the Loan Agreement. This problem, however, will be relieved when water flows (and power sales) return to normal levels in the near future. The rate of return of KOWACO's Water Division also declined from 7% in 1987 to 3% in 1988. This is a temporary problem, partly due to the drought and partly due to the sudden entering into operation of several large systems (which doubled the Division's assets during 1987-89). Since water systems are designed for the capacity required up to ten years after construction, it is not possible to obtain a satisfactory rate of return during the first or even the second year of operation of a new system. KOWACO was also forced at this time to take over an over-designed and very expensive water supply system (Geum Gang), for which current national water rates cover only about one third of costs. Nevertheless the rate of return, even using tariffs below levels recently approved by the President, should be 5% in 1991 and higher thereafter. These rates are based on fully revalued assets. Other than in 1988, KOWACO's financial position was generally satisfactory, as indicated by good debt service ratios, the contribution to investment, and cash reserves.

16. The project's environmental achievement is particularly noteworthy. The project was designed not only to minimize the potential environmental damage associated with barrage construction but also to protect the bird habitat in the Nakdong estuary from development. Therefore, as agreed under the loan, a 34.2 sq km area of mud flats, islands and wetlands in the Nakdong estuary was declared a NEPA by MOC (in December 31, 1988) and a Natural Ecological System Preservation Area (NESPA) by the Office of the Environment (in March 1, 1989), thus giving this important migratory bird sanctuary the maximum protection from development available under law. This was the first area ever to be provided such protection in Korea. Other environmental control measures were also introduced in the area surrounding the NEPA to further protect the bird habitat. Although the project's

environmental targets were probably too ambitious, they were nevertheless successfully achieved.

17. At completion, the project cost was about US$218 million, 31% higher than expected due mainly to the inclusion of additional works (establishment of a flood forecasting system, 140 ha of additional land reclamation, full development of the reclaimed land and increased compensation costs, particularly for fisherman, see Part II, Tables II-5 and II-6). Land and barrage construction accounted for about 98% of the total cost of the project and the two institutional development programs for the remainder. Due to savings resulting from a decrease in the exchange rate between the won and the US dollar, lower than expected bids for equipment and consultant services, and KOWACO's higher self-financing capacity, only about 65% of the loan was disbursed and US$27.2 million of the loan amount was cancelled in stages throughout the project period (see Part III, Table 3). KOWACO and some government equity contributions covered the remaining costs. Even with the increase in project cost, the rate of return of the project was very high (20%) and similar to the original appraisal estimate of 24% (Part III, Table 6).

Sustainability

18. The project's achievements are expected to be fully sustainable. Barrage inspection and maintenance manuals prepared under the project should ensure optimal operation of the facility, as will the adequate complement of offices, equipment and staff provided by KOWACO for this purpose. The flood protection and warning system included in the project will allow better operation of all water structures in the river and better protection of the population living near the river against floods during the monsoon season. The leak detection and environmental capabilities established under the project will ensure that such efforts will continue in the future. Permanent units for leak detection and control were created in the project WBs and provided with equipment. The Environment Management Unit and the Environmental Research Division established in KOWACO will monitor water quality at eight points on the river as well as biological and ecological parameters, e.g., the avian population, phytoplankton, sediments, etc.

19. Some project benefits, like the protection of water quality, reduction of water leakage and protection of the environment, would be expanded at a national level during 1990-95 by a National Water Improvement Program (NWIP). The NWIP includes (a) expanded leak detection efforts and replacement of about 27,500 km of corroded/leaking pipes and (b) increased protection of Korean rivers through the provision of government financing for the relocation of 550 industries nationwide before 1992, the modernization/rehabilitation of 20% of the country's water treatment plants and significant expansion of sewage treatment works totaling some W 2,160 billion, with 80% grant financing. The improved financial performance of KOWACO sought under the project, partly through increased water tariffs, should also benefit from the 30% increase in water tariffs during 1990-92 approved by the President in conjunction with the NWIP. Because of KOWACO's institutional success, the Government may give KOWACO full responsibility for management of water quantity, quality and sewage treatment of the main rivers, including the Nakdong. This should help to further improve environmental conditions throughout entire basin areas.

Bank Performance

20. The Bank was particularly active throughout the course of this project in ensuring that the project objectives were attained. Bank supervisory staff attempted to assist Pusan to complete the interceptor by preparing a possible financing plan and exploring the possibility of government funding for this activity. More notably, Bank staff and management were significantly involved in ensuring achievement of the project's environmental benefits, which necessitated continued attention throughout project preparation, construction and operations. As noted in para. 7, Bank involvement in the design selection process resulted in the choice of a more environmentally acceptable design alternative. Bank efforts to ensure careful control of construction and dredging during the construction period also eliminated or greatly reduced environmental damage.

21. Bank staff and management also devoted considerable time to ensuring that the ecologically sensitive areas of the Nakdong estuary were given full legal protection from development, as stipulated in the Loan Agreement. This was a more difficult task than expected since Pusan City badly needed additional land due to its hilly terrain, difficult geographical position and high population density (one of the highest worldwide). Pusan's development plan included the reclamation of 64 sq km in the middle of the estuary for an industrial site. However, the Bank was not officially informed about these plans until late-1985, when it also learned that a national law had expanded the city's boundaries to included the entire estuary area and that no environmental protection could be provided for such areas. Since these changes went counter to the Loan Agreement, the Bank made a strong representation to the Government to halt the proposed development. This resulted in moratoria on development and construction in the estuary area, during which time the long and very difficult process of gaining legal protection for the area was undertaken. A satisfactory agreement was finally reached, under which reclamation was limited to an area covering only 11.7 sq km outside the critical estuary area, including 1.7 sq km of mud flats and 10 sq km in an outlying and environmentally less sensitive area. Bank management also participated in gaining agreement that strict environmental guidelines would be enforced to limit industrial pollution of the protected area, through pre-treatment of all industrial wastes, the use of liquified natural gas rather than coal as fuel in the surrounding area to prevent air pollution, the creation of greenbelt buffer zones to shield the preservation area from industrial pollution, and the construction of 3 sq km of additional mud flats and grass fields on an estuary island.

22. Bank staff provided steady, continuing encouragement to MOC, which was responsible for guiding the NEPA initiative through a labyrinthine legal and administrative approval process. The critical estuary area now has the maximum ecological protection that can be provided in Korea.

23. The lessons learned under the project were: (a) the advanced state of project preparation and the procurement of construction under a single contract greatly reduced the project cost (60% of the initial engineering estimates) and simplified implementation; (b) environmental protection requiring changes in laws or regulations is difficult and requires a long lead time to gain consensus on issues affecting a number of government agencies with varying

interests and objectives; (c) the transfer of technology to many cities, particularly for accounting and leak detection, can be carried out successfully at minimum cost; and (d) covenants which are realistic and achievable result in compliance.

Borrower Performance

24. KOWACO's impressive technical capabilities and experience resulted in its completion of a large and complex hydraulic structure in the record time of less than four years. The performance of MOHA in implementing the leak detection and accounts computerization programs was also satisfactory, although the component could have been completed earlier. The project's positive environmental impact is testament to the cooperation of the Korean authorities, particularly KOWACO, MOC and its National Physical Planning Bureau, which showed responsiveness to the Bank's suggestions on project design and persevered in pursuing establishment of the NEPA despite various difficulties. The Office of Environment also showed rapid responsiveness in providing strong support for inclusion of the largest possible area in the NEPA and establishing the NESPA soon after the NEPA was legally established. The agencies' compliance with Loan/Project Agreement covenants is detailed in Part III, Table 7.

Project Relationships

25. Despite the existence of several contentious issues related to the project, the Bank's relationship with the Government in general and the implementing agencies in particular remained amicable throughout. Maintenance of this very constructive relationship was crucial to the eventual resolution of the environmental issue, which threatened to become a serious problem for both the Government and the Bank. The particularly good relationship which has developed among the Government, KOWACO and the Bank in the course of several projects also facilitated a general dialogue on government plans to improve water resources management, in part by strengthening KOWACO's role in the sector. These plans have now materialized, as indicated by the NWIP, and the condition of Korea's water resources and its water supply and sewerage sector should be significantly improved, where needed, over the next five years.

Consulting Services

26. Consultants were engaged under the project to supervise project construction and environmental management, to help prepare the National Leak Detection Program, to assess requirements for computerization of Water Bureau accounts, and to carry out various environmental impact studies, including a study to identify the estuarine area requiring maximum protection as a NEPA. The performance of these consultants was satisfactory (see Part II, para. 1.22).

Project Documentation and Data

27. Project documentation was generally adequate. Although a Project Agreement with Pusan City might have helped to gain greater cooperation from the city in implementing complementary investments, little could be done to hasten implementation in view of the city's near bankrupt financial condition and its refusal to accept Bank financing for this investment. The availability of data

for project monitoring was satisfactory; a system of computerized financial projections for KOWACO, which was prepared by Bank staff, was used routinely and facilitated monitoring of KOWACO's performance.

PROJECT COMPLETION REPORT

KOREA
SECOND WATER SUPPLY PROJECT
(LOAN 2350-KO)

PART II: BORROWER REVIEW OF THE PROJECT

1. Project Identification and Preparation

1.1 Introduction. The Nakdong River Basin has an area of some 23,600 sq km and covers one fourth of the total area of Korea (see Map II-1). Integrated land and water resource surveys and studies of the basin had been conducted since 1966. On the basis of these studies, a schedule of major dam construction was prepared to meet the increasing demand for water in the area, including the requirements for controlling salinity intrusion by excess water flows. The Andong Multipurpose Dam, put into operation in 1977, was expected to offer relief against salinity intrusion for some years to come. However, accelerated development within the country required a more up-to-date management plan for water conservation and salinity control in the tidal reaches. Accordingly, the Nakdong estuary barrage was proposed as the next priority structure for construction to guarantee a continued water supply for irrigation, municipal and industrial purposes and to solve increasing salinity problems.

1.2 Origin and Formulation. Construction of the barrage was proposed as one of the most economical investments for increasing available water resources in the Nakdong River Basin, as indicated by basin-wide investigations and studies including the Nakdong River Basin Preinvestment Survey (UNDP/FAO, November 1966 - March 1972), the Nakdong Basin Study (MOC, March 1973) and the Nakdong River Basin Development Project Feasibility Study (Nippon Koei, 1976). The Nakdong Delta Study (UNDP/FAO, 1974-77) and the Feasibility Study (NEDECO, 1976) identified the project as the least-cost solution to solve salinity problems in the estuary and to make available some 25 of the 40-50 cu m/s of water needed for salinity repulsion in the absence of the barrage.

1.3 Preparation and Appraisal. Preliminary and detailed designs for the barrage were financed by the Bank under the Chungju Multipurpose Project (Loan 1666-KO) and were carried out by NEDECO during 1980-83. KOWACO provided technical counterparts to assist design consultants mainly in site surveying and investigations. The Ministry of Construction was the cooperating government agency. The overall design was reviewed by an Expert Review Panel (ERP) established by KOWACO in consultation with the Bank. As agreed by the ERP, KOWACO, NEDECO and the Bank, the design and the contract document were modified (para. 2.11) and finalized, and the project was appraised by the Bank based on the final design in May 1983.

1.4 Objectives. The objectives of barrage construction were as follows:

(a) Salinity Repulsion. Water withdrawals from the river and its tributaries for municipal and industrial use were rapidly increasing. Water balance calculations and observations indicated that under drought conditions: (i) daily flows would be at critically low levels and would hardly match daily withdrawals or would be too low to prevent an unacceptable salinity level at the major water intakes in the lower reaches of the river; and (ii) in the near future, water

requirements could overtake discharges. Releases from upstream reservoirs were possible to mitigate salinity problems. However, during periods of low river discharges coinciding with peaks in agricultural water demands, it would be very difficult to ensure proper water distribution in the river system and hence a substantial portion of reservoir releases might not reach the river mouth. The barrage would eliminate salinity problems at the water intakes for Pusan and the Gimhae agricultural areas in the lower reaches of the river, and make available about 25 cu m/s of water which would otherwise be released to the sea to prevent salinity intrusion.

(b) Land Reclamation and Traffic. Land is scarce in the densely populated Pusan region, and urban areas are interspersed with industrial sites, which is highly undesirable. Land reclamation for the resiting of industrial complexes would relieve this situation. Furthermore, a road on top of the barrage would serve as part of the public road network which would divert some traffic from existing bridges. Such a road would also considerably facilitate limited urban development in the southern part of the Gimhae polder.

(c) Institutional Development. The project would help to implement sound financial and water pricing policies in KOWACO.

(d) Environmental Protection. The project would also help to protect the Nakdong River's estuarine environment and to develop KOWACO's environmental management expertise.

1.5 Project Description. The project comprised construction of the Nakdong estuary barrage and reclamation and environmental monitoring (see Table II-1 for details).

(a) Barrage Construction. The barrage is located at the mouth of the Nakdong River estuary which has two branches separated by Eulsuk Island (see Map II-2). The main barrage works comprised construction of the 510 m long concrete box girder bridge and ten radial gate structures built on the left branch to control the river flow. A 700 m long closure dam closes the right branch and is connected to the 1,200 m long dike across Eulsuk Island which is flanked on the west by the barrage. Barrage construction also allowed the construction of a four-lane road atop the barrage across the Nakdong River mouth from Pusan to the west and Gyung Nam Province.

(b) Land Reclamation and Drainage System. South and north of the barrage alignment, 190 ha of land reclamation was originally proposed, and an additional 140 ha of reclamation along the south coast was included during project implementation, bringing the total to 330 ha. The drainage system consists of four pumping stations with retarding basins and 15 km long main discharge channels. The drainage system covers the entire reclaimed area and about 1,200 ha of an adjacent low-lying inhabited area.

(c) Appurtenant Works. A discharge sluice on the eastern part of Eulsuk Island serves the ecology downstream of the closed right river branch and ensures adequate water quality in the dead river (upstream of the right branch) by means of flushing, with a maximum discharge of 150 cu m/s. A navigation lock (9 m by 50 m) for the passage of sand barges and fishing vessels is situated to the west of the barrage on Eulsuk Island. Other appurtenant works include viaducts, dikes, approach channels, fish passes, a flood forecasting and warning system, and service and operation facilities.

(d) Environmental Monitoring. The project included the systematic monitoring of the environment in the Nakdong estuary both during and after construction of the barrage, and the provision of microcomputer hardware and software for environmental and financial management. KOWACO established and maintained an Environment Management Unit (EMU) including expatriate environmental experts supported by KOWACO's staff, and also executed monitoring of the estuarine environment, ecological impact studies and preparation and implementation of its environmental protection program during construction.

2. Implementation

2.1 Loan Effectiveness and Project Start-Up. The Loan Agreement was signed between the Government and the Bank on October 21, 1983 and declared effective on January 11, 1984. The Project Agreement covering the Nakdong barrage component was signed between KOWACO and the Bank. The Government, which was the borrower of the loan, relent the loan amount for the Nakdong barrage component to KOWACO on the same terms and conditions as the Bank loan plus a 0.05% p.a. handling charge. There were no special problems in the start-up period. During this time, KOWACO prepared the Environmental Impact Assessment (EIA) for barrage construction, and the EIA was approved by the Office of the Environment (OOE) contingent upon KOWACO's establishing an Environment Management Unit (EMU) to survey and monitor the bird habitat and taking countermeasures to minimize adverse effects during and after construction. The Ministry of Culture and Information approved the construction of the barrage and excluded the project reclamation area from the defined area of National Monument No. 179 (comprising the bird sanctuary in the Nakdong estuary, para. 2.10) according to KOWACO's request.

2.2 Revisions. No significant revisions of the original project were made. However, some additions, including facilities for operation and maintenance of the barrage and part of the infrastructure for the reclaimed area, were made in the project scope as listed below:

(a) additional reclamation of 140 ha of land in the Jangrim/Dadae area was carried out, bringing total land reclamation under the project to 330 ha;

(b) drainage facilities, comprising four pumping stations with a retarding basin and 15 km of main drainage channel, were provided for the reclaimed as well as an adjacent developed area;

(c) ten bridges were constructed across the existing channel extension through the reclaimed area; and

(d) a flood forecasting and warning system was installed, covering the entire Nakdong basin area.

Infrastructure, such as roads, water supply, a sewage pipeline and electricity distribution lines, were provided under a separate locally-implemented project, in accordance with Pusan's Master Plan. Details of project revisions are given below.

2.3 Additional land reclamation was carried out under the project in the Jangrim/Dadae area on a relatively narrow strip of land extending from the Jangrim tributary (cheon) southward to near Dadaepo beach, which had been designated for reclamation under the National Land Use and Management Law of December 31, 1983. In the original design, the reclamation was to be executed by using coarser sands mainly from borrow areas outside the channel excavation areas, and most of the excavated soil with high silt content was to be spoiled to the sea area. However, the application of hydro cyclones lowered the content of finer particles in the dredged materials from channel excavation and made them available for the fill works. Accordingly, the extension of land reclamation under the project was reviewed and approved in order to dispose of the remaining excavated sand, after filling in the originally designated reclamation area. The total amount of sand fill used for the project's land reclamation activities reached 16 million cu m, which was about 67% of the total excavation of 24 million cu m from the channels. A study of the morphology and back-water effects of the additional fill work indicated a considerable reduction of the cross sectional profile of the eastern river branch in the estuary, with higher water levels than in the original design occurring about 0.3 km upstream of the barrage. However, only a small increase in the risk of inundation was expected from the additional reclamation, even in the absence of flooding countermeasures. Moreover, the increased risk of inundation would occur only just after completion of the barrage, since nature tends to restore a disturbed equilibrium. As the study revealed, it is likely that the eastern tidal channel will ultimately be developed to become the main channel.

2.4 Drainage facilities were planned and executed as part of the infrastructure of the reclaimed area. In the design phase of the project, the drainage of adjacent areas was reviewed and included in the project scope. The original drainage plan was based on the Pusan Sewerage and Drainage Master Plan drafted in 1974, and mainly dealt with sewage disposal and excess urban rainfall discharged directly into the river. An essential part of the Master Plan was the installation of a separate system for sewage transport through closed conduits, with the main collector running from the north to the south along the Nakdong River to a purification plant near the river mouth. By the end of 1970, implementation of the Master Plan had been limited to flood control works like dikes and primary drains. Therefore, sewage disposal would be impeded by construction of the barrage, and a drainage plan was consequently needed to maintain the quality of water in a small and shallow surface water reservoir created by the barrage construction. This was thoroughly discussed with the Pusan City authorities, who envisaged an early commencement of the necessary works according to the Sewerage and Drainage Master Plan. Accordingly, the

drainage system originally included in the project design was deleted during project formulation, and the drainage facilities provided under the project were designed to handle only the excess rainfall in the reclaimed area and the limited adjacent areas where direct discharges would be impeded by barrage construction. Sewage transport and a collector system and treatment plant are being executed as a separate project by Pusan City. The main features of the drainage system are shown in Table II-2.

2.5 Ten bridges were designed and built for road connections where the road crosses the channel extensions. There are five channel outfalls on the west bank side of the project area which discharge excess rainfall from the adjacent areas. Barrage construction was to impede discharges into the river from these outfalls. Channel extensions were therefore designed running through the reclamation area to provide drainage of the existing basin area including the newly reclaimed area. The road system in the reclaimed area was established by Pusan City according to its Land Use and Urban Development Master Plan.

2.6 A flood forecasting and warning system was established for basin-wide flood control and quantitative water management. The system consists of 52 rain and 33 water-level gauges, a microwave transmission system to collect data, and a data processing and warning control system in the main service center on Eulsuk Island.

2.7 Implementation Schedule. The project was implemented between October 1983 and June 1988. A comparison of planned and actual execution of works is given in Table II-3. Construction of the barrage began in November 1983 and was completed in November 1987, two months sooner than expected. Operations of the bridges and maingates, the navigation lock and the discharge sluice started thereafter. Minor project works were completed by June 1988.

2.8 Initially, barrage construction was frequently hampered and interrupted by demonstrations, blockages and occupations by people living in the periphery of the project area. These problems were related to the acquisition of land and various aspects of compensation, which were not fully settled prior to the commencement of works (para. 2.14). In addition, two major river floods passed the construction site in the wet season of 1984 when the building pit for the barrage main works was under construction, and typhoon "Thelma" passed over the project site in July 1987, when major works were mostly completed and after closure of the western river branch. The floods and typhoon caused minor damage to the project works but seriously damaged the houses of the neighboring inhabitants and resulted in demonstrations and occupations of site offices and works by the injured inhabitants. These problems caused about eight months slippage in the construction schedule, but were effectively compensated for by accelerating construction works. The land acquisition and compensation problems were fully settled during the construction period.

2.9 Procurement. All civil works and equipment for the barrage, estimated at US$81 million in 1983 U.S. dollars, were procured through international competitive bidding (ICB) following Bank guidelines. Procurement of all supplies and construction for the barrage and appurtenant works was under one contract to ensure proper integration of the different project components and early completion of works. Technical specifications and bidding documents

were reviewed by the Bank. Advance contracting had been included, given the urgent need to begin construction in October 1983 at the start of the dry season to avoid a year's delay in project completion. Six joint ventures and four local contractors presented bids on August 10, 1983. The contract was awarded on September 10, 1983 with Bank concurrence. The Bank indicated that advance contracting was undertaken at the Government's risk and that Bank financing of the project was contingent on the Board's approval of this project. Advance contracting reduced the estimated project cost and foreign cost component since actual bids were 36% lower than engineering estimates. This was mainly the result of Korea's highly competitive construction industry and some alternative technical solutions proposed by the bidders.

2.10 Environmental Monitoring and Management. The Nakdong estuary is a wintering place for migratory birds from the Arctic region. The main areas of the estuarine habitat were declared a National Monument, No. 179, by the Government in 1966. The designated area is about 240 sq km, including the entire project area, and disturbance of the bird habitat was strictly prohibited. In the preparation of the project, it was well recognized that adverse effects on the environment had to be minimized and the bird habitat preserved; designs for the project therefore incorporated features for this purpose.

2.11 KOWACO prepared an Ecological Impact Assessment (EIA), based on the design consultant's recommendations, and OOE approved the project, subject to conditions designed to minimize adverse effects on the environment. Subsequently, the Ministry of Culture and Information excluded the reclamation area of 190 ha and the project works from National Monument No. 179 according to KOWACO's request. In the course of project implementation, KOWACO also prepared an EIA for the additional reclamation area (Jangrim/Dadae) and changed land use, according to the Pusan Master Plan. OOE approved the additional reclamation and changed land use, and the Ministry of Culture and Information excluded 140 ha of additional reclaimed area from National Monument No. 179.

2.12 KOWACO fully complied with the conditions recommended by OOE through its Environment Management Unit (EMU). The EMU was established at the Pusan Project Office at the beginning of project implementation in 1983, and comprised local and foreign environmental specialists. The Unit operated satisfactorily during the project period. KOWACO also established an Environment Management Section at headquarters in September 1983, which is responsible for overseeing and assisting environment-related activities of the EMU and the Pusan Project Office. This section has expanded and developed into a department for environmental management of all KOWACO projects.

2.13 Increased demand for more urban and agricultural land due to population growth could lead to the reclamation of areas in the Nakdong estuary essential for the preservation of the bird habitat. Therefore, one of the major works of the EMU was to carry out a study identifying areas which are vital for the continued preservation of the bird habitat. The EMU executed the study in accordance with terms of reference acceptable to OOE and the Bank, and proposed the boundaries for a Natural Environment Preservation Area (NEPA) and a Natural Ecological System Preservation Area (NESPA) in the estuary. Based on the results of this study and recommendations of EMU, MOC designated a NEPA of about 34 sq

km under the National Land Use and Management Law on January 10, 1989 (Map II-3), and OOE designated the NESPA in March 1989.

2.14 Land Acquisition and Compensation. For the project, 2.2 million sq m of land were acquired and compensation was provided for 924 houses and other buildings, fishery and public facilities, etc. within the project area and in its vicinity. Costs for land acquisition and compensation totalled US$37.56 million in 1988 U.S. dollars. Details of land acquisition, compensation and the related costs are given in Table II-4. In addition, 786 households of inhabitants within the project area and its vicinity were resettled on the newly reclaimed land in the Shinpyong and Myongji Dong. Resettlement areas covered 79,900 sq m and 32,000 sq m, respectively, and were fully provided with public facilities, including roads, potable water supplies, drainage and sewerage collectors, electricity, etc.

2.15 Costs and Disbursement. At project appraisal, the total cost of constructing the Nakdong barrage was estimated at US$167.02 million, including physical and price contingencies, of which US$73.32 million or about 44% represented foreign exchange. The actual cost of this component was US$212.43 million equivalent or about 27% above the estimated cost, largely due to the additional works described in paras. 1.7-1.11. However, the cost of consultants for the supervision of barrage construction and environmental management support to KOWACO was estimated at US$5 million but the actual cost was US$3.28 million equivalent. A comparison of estimated and actual costs is given in Table II-5 and the actual cost by year is given in Table II-6.

2.16 The Bank loan of US$73.50 million for the barrage was to be disbursed against:

(a) 55% of the contract for the barrage (which included civil works and equipment);

(b) 100% of local expenditures (ex-factory cost) and 100% of the foreign expenditures for computer hardware and software, and equipment for monitoring the environment;

(c) 100% of the initial mobilization payment for the barrage; and

(d) 100% of the cost of consulting services.

The actual disbursement of the loan amounted to US$47.73 million, which was 65% of the original loan amount for this component. Tables II-7 and II-8 give details of loan disbursement for the Nakdong component.

2.17 Consulting Services. Under the project, consultants were engaged to help supervise barrage construction and to assist in studying and planning the environmental protection of the Nakdong estuary (1983-85). The major assistance and services rendered by the consultants are summarized below:

For Barrage Construction

(a) advise on the approval of the contractor's work program, working methods, proposals for plant, equipment, key personnel, etc;

(b) assist KOWACO's Resident Engineer in checking and giving final approval of all working and shop drawings submitted by the contractor;

(c) prepare additional detailed designs and design calculations;

(d) inspect the progress of the project works and their conformance to contract specifications;

(e) provide on-the-job training to KOWACO's supervision staff; and

(f) prepare operation and maintenance manuals for the barrage.

For Environmental Protection

(g) assist KOWACO in drafting and carrying out an ecological research program for the Nakdong estuary,

(h) assist KOWACO in selecting suitable Korean personnel to carry out parts of the ecological research;

(i) assist KOWACO in setting up an administrative and organizational framework to carry out research and to implement environmental management;

(j) provide guidance on matters of environmental protection during the construction phase;

(k) assist KOWACO in drafting an environmental management plan for the Nakdong estuary, including guidelines for maintenance dredging, operation of the barrage and discharge sluice, sewage disposal, land reclamation and land use;

(l) assist KOWACO in drafting an environmental monitoring program and in initiating program implementation; and

(m) train Korean staff, where necessary.

2.18 Water Demand and Sales. The projection of total water demand for municipal and industrial use in the Nakdong River Basin is shown in Table II-9. The projection was based on government population forecasts and the estimated per capita water production for the 37 municipalities which depend on the Nakdong River or its tributaries for water supply. The population, service levels, per capita production forecasts and resulting water demand projection are presented in Table II-10. The main water users are Pusan, Ulsan/Onsan and Daegu, which represent about 80% of total municipal and industrial water demand. A projection of incremental water demand (base year of 1982) shows that the water made

available by the barrage operation would be fully used by 1994. According to a demand projection made by KOWACO and the project consultants (NEDECO), agricultural water demand will increase by only some 140 million cu m per year until 1991, and will largely coincide with low river flows in May and June.

2.19 Total sales of municipal and industrial water are estimated at 450 million cu m per year. The estimate is based on the incremental water demand served by the main river, excluding its tributaries.

2.20 Tariffs. The water tariffs used by KOWACO s Dams Division were formerly proportional to the cost of each system; however, in 1987 a nationwide single tariff was introduced. Municipal and industrial water made available by the barrage will also be charged at the single rate of W 5.94 per cu m (compared to the W 7 per cu m used in appraisal estimates) which was agreed between the concerned government Ministries in 1987. Sale of the land reclaimed and developed under the project is expected to bring in about US$302.4 million (see Table II-11).

3. Financial Performance

3.1 KOWACO's Financial Status. KOWACO's authorized capital is W 1,500 billion. Its paid capital of W 557.8 billion consists of W 321.8 billion transferred in goods, W 234.5 billion transferred in cash and the W 1.5 billion surplus transferred into capital.

3.2 The ratio of costs to sales (the operating ratio) averaged almost 88% a year during FY83-88 as against almost 99% during FY78-82; the 11% drop resulted in a great improvement of profit to sales and was due to deferred earnings from the sale of land for new town projects. The operating ratio for dams projects has averaged 87.4% a year during FY83-88 as against 110% in FY82 and has shown great improvement. The current ratio, which represents the liquidity of a firm, was 0.86 in FY82 and increased to more than 1 during FY83-88 as a result of deferred earnings from remaining new town projects and of increased water demand registered by the Dams Division. The debt-to-equity ratio, which represents the stability of a firm, averaged 53.6% a year during FY78-82, but dropped by 40.6% during FY83-88, resulting in a great improvement (see Tables II-12 and II-13).

4. Institutional Performance

4.1 Management and Organization Effectiveness. KOWACO, the main executing agency for the Nakdong barrage, was established on February 1, 1974 for the development of: (a) industrial sites, (b) water resources for irrigation, flood control, power generation, industrial and municipal water supply, and (c) operation and maintenance of multipurpose dams and facilities to provide bulk water for industrial and municipal consumption. On July 1, 1988, its duties were rationalized and it was made Korea's main institution for water resources development and management.

4.2 KOWACO is currently managed by a Board of Directors consisting of a President, one Vice President and six Directors (Planning, Administration, Dam Management and Maintenance, Water Supply and Public Utilities, Dam Construction

and Industrial Sites). KOWACO has developed into a large and competent organization during the past decade. It has expanded its organization from 16 departments at the Daejon head office, 17 local offices and 1,214 employees in 1983 to its present 23 departments, 24 local offices, and 2,028 employees.

4.3 In 1983, KOWACO established a department at its head office and a local office at the Pusan site to handle project implementation. The site office was also in charge of the operation of the project after completion in 1988. These organizational arrangements ensured effective implementation of the project. Key KOWACO staff with experience in the execution and management of water resources projects were employed for the Nakdong project; they were well Staff were engaged in the inspection, installation and performance testing of equipment and became thoroughly familiar with the equipment and its operation. The main contract and consulting services provided for on-the-job and overseas training of key staff.

5. Project Justification

5.1 Municipal and Industrial (M/I) Water. Actual M/I water withdrawals in the Nakdong Basin between 1981 and 1985 increased at the rapid rate of some 7.0% per year. In the estuary area, water withdrawals increased at about 16% for the main cities including Pusan, Ulsan, etc. (Table II-9). Under the present drought conditions, the water supply in the cities of Pusan and Ulsan would have inevitably been stopped for hundreds of hours each year without the barrage. The river flow required for salinity repulsion is estimated at about 40 cu m/s. The barrage operation makes available to the cities about 25 cu m/s of water (totalling up to 750 million cu m per year), which would otherwise be used for salinity repulsion. The remaining 15 cu m/s of flow has been maintained to allow for dilution, navigation, fisheries and to provide nutrients to the estuary area.

5.2 Agriculture. Operation of the barrage eliminates salinity problems in the Ginhae polder area which is one of the most productive agricultural areas in Korea. Its original intake at Daedong had to be abandoned due to salinity intrusion, and prior to the project the present intake at Weolcheon had already experienced salinities over 2,000 parts per million. This situation would have resulted in gradual deterioration of agricultural productivity in the polder area. With the barrage, the intakes at both Daedong and Weolcheon supply salinity-free water, which has allowed intensification of agriculture and higher productivity in the polder area.

5.3 Land Reclamation. The land reclaimed and developed under the project is extremely valuable for the densely populated Pusan region. Pusan City plans to use this land to resite some of the industrial complexes now interspersed in the urban area and to develop a residential area and public utilities. This will help to relieve the current undesirable situation resulting from the scarcity of land in the region.

5.4 Traffic. A four-lane roadway on the barrage has improved access to the southern part of the Komhae region and reduced travel distances by about 10 km. The bridge, which is part of the public road network, diverts traffic from existing bridges on the river in the estuary. This will facilitate urban development of the Kimhae polder, thus increasing the value of this land.

MAIN FEATURES OF THE NAKDONG BARRAGE

Table II-1

GENERAL , FLOOD & WATER LEVEL

*.CATCHMENT AREA : 23,600 km^2

*.DESIGN DISCHARGE : 18,300 m^3 / s (500 YEARS RETURN PERIOD)

*.NORMAL OPERATING WATER LEVELL : EL + 1.0 m(+ 0.25 m) SMSL (STANDARD MEAN SEA LEVEL)

*.DESIGN FLOOD WATER LEVEL : EL + 3.8 m SMSL

BARRAGE AND CLOSURE DAM

*.TOTAL LENGTH : 2,400 m

*.CLOSURE DAM AND DIKES : 1,890 m

*.BARRAGE : 510 m

BARRAGE GATE

*.6 MAIN GATES : W 47.5 m * H 8 m , WEIGHT 250 tons / gate

*.4 REGULATING GATES : W 47.5 m * H 6.75 m , WEIGHT 250 tons / gate

BRIDGE

*.4 LANE (18 m) PRESTRESSED CONCRETE BOX GIRDER

NAVIGATION LOCK

*.W 9 m * L 50 m ; WITH 2 SETS OF MITRE GATES

DISCHARGE SLUICE

*.W 3.7 m * h 4.9 m ; WITH 2 VERTICAL ROLLER GATES

LAND RECLAMATION

*.330 ha (FORMATION LEVEL : EL + 2.2 - 3.7 SMSL)

DRAINAGE FACILITIES

*.MAIN CHANNEL 11.82 km

*.4 PUMPING STATION WITH RETARDING BASIN

FLOOD FORECASTING AND WARNING SYSTEM

*.52 RAIN FALL GAUGES

*.33 WATER LEVEL GAUGES

*.3 WATER QUALITY STATIONS

*.1 MONITORING & WARNING CONTROL STATION

10 BRIDGES ON RECLAIMED AREA

Table II-2

MAIN FEATURES OF THE DRAINAGE FACILITIES

A. MAIN CHANNEL

* CONCRETE PIPE : D=800 ~ 1350 m / m , L=1,070 m
* CONCRETE BOX CULVERT : B 1.0 * H 1.5 ~ B 3.5 * H 2.5 , L=4,270 m
* CONCRETE LINED CHANNEL : B = 1.0 ~ 5.0 m , L = 4,790 m
* BLOCK LINED CHANNEL : B = 1.0 ~ 12.0 m , L = 1,690 m
* INVERTED SYPHON : 2 ea (CROSSING HAKJANG & GOEJEONG CHEON EXTENTION)

TOTAL LENGTH : 11.82 km

B. PUMPING FACILITIES

HAKJANG I

* DRAINAGE BASIN AREA : 0.63 km^2
* RETARDING BASIN AREA : 4,120 m^2
* MOTOR PUMP : 125 kw * 2 sets (CAPACITY : 190 m^3 / min)
* ENGINE PUMP : 320 Hp * 1 set (CAPACITY : 95 m^3 / min)
* EMERGENCY GENERATOR : 1000 kw * 1 set

HAKJANG II

* DRAINAGE BASIN AREA : 0.02 km^2
* MOTOR PUMP : 19 kw * 2 sets (CAPACITY : 12 m^3 / min)

GOEJEONG

* DRAINAGE BASIN AREA : 1.80 km^2
* RETARDING BASIN AREA : 6,270 m^2

*.MOTOR PUMP : 200 kw * 3 sets (CAPACITY : 190 m^3 / min)

*.ENGINE PUMP : 355 Hp * 2 sets (CAPACITY : 190 m^3 / min)

*.EMERGENCY GENERATOR : 1000 kw * 1 set

JANGRIM

*.DRAINAGE BASIN AREA : 1.93 km^2

*.RETARDING BASIN AREA : 7,030 m^2

*.MOTOR PUMP : 200 kw * 3 sets (CAPACITY : 190 m^3 / min)

*.ENGINE PUMP : 320 Hp * 2 sets (CAPACITY : 190 m^3 / min)

*.EMERGENCY GENERATOR : 1000 kw * 1 set

Table II-3

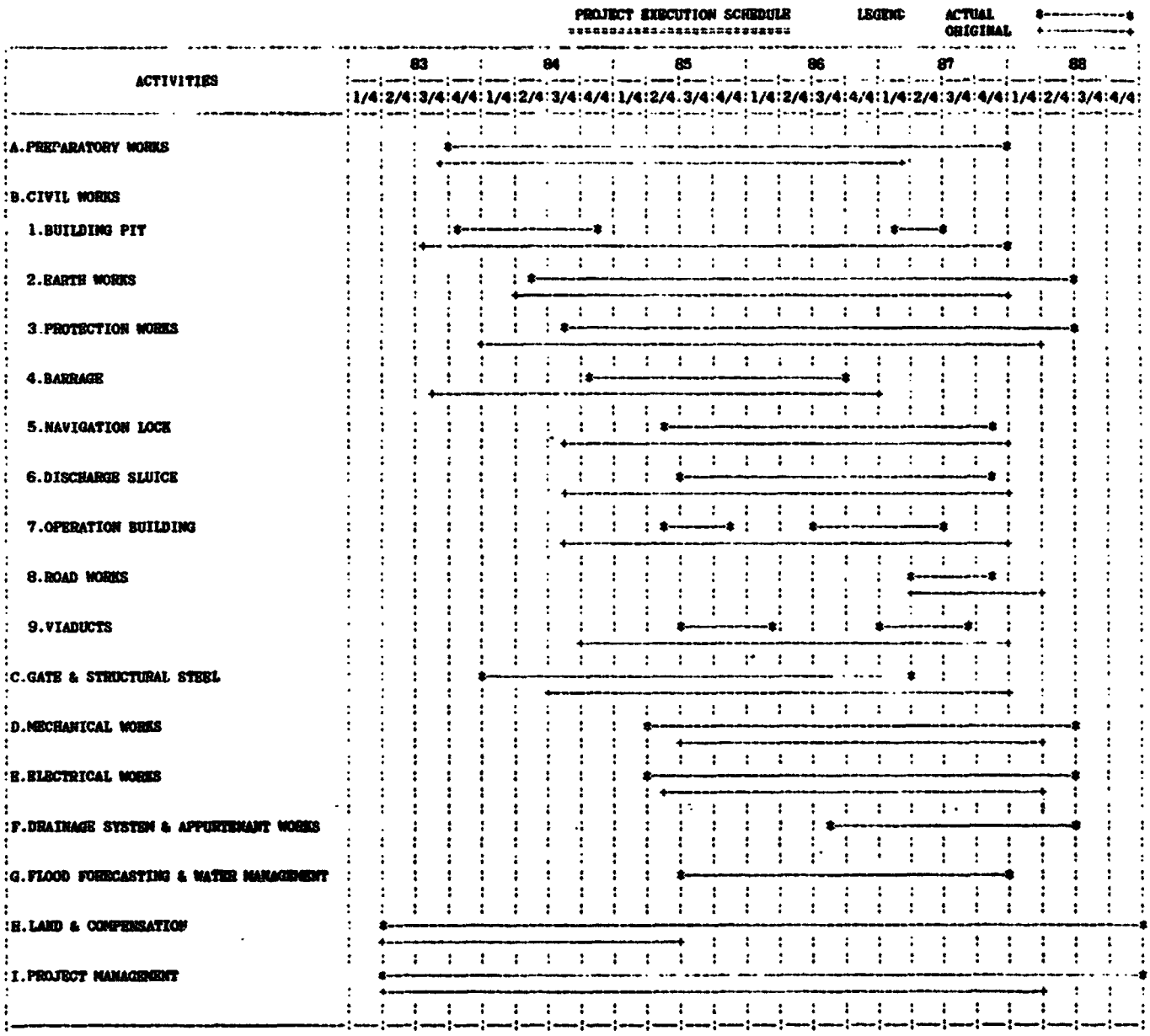

PROJECT EXECUTION SCHEDULE
LEGEND
ACTUAL
ORIGINAL
ACTIVITIES
83
84
85
86
87
88
1/4 2/4 3/4 4/4 1/4 2/4 3/4 4/4 1/4 2/4 3/4 4/4 1/4 2/4 3/4 4/4 1/4 2/4 3/4 4/4 1/4 2/4 3/4 4/4
A.PREPARATORY WORKS
B.CIVIL WORKS
1.BUILDING PIT
2.EARTH WORKS
3.PROTECTION WORKS
4.BARRAGE
5.NAVIGATION LOCK
6.DISCHARGE SLUICE
7.OPERATION BUILDING
8.ROAD WORKS
9.VIADUCTS
C.GATE & STRUCTURAL STEEL
D.MECHANICAL WORKS
E.ELECTRICAL WORKS
F.DRAINAGE SYSTEM & APPURTENANT WORKS
G.FLOOD FORECASTING & WATER MANAGEMENT
H.LAND & COMPENSATION
I.PROJECT MANAGEMENT

Table II-4

LAND ACQUISITION & COMPENSATION

UNIT : THOUSAND US $

	UNITS	AREAS & NUMBERS	COSTS	REMARKS
*.LAND ACQUISITION	SQ m		10,747	
-FARM LANDS	"	33,600	1,200	
-BUILDING LOTS	"	5,900	742	
-OTHERS	"	2,160,500	8,805	
*.COMPENSATIONS			23,026	
-HOUSES & BUILDINGS	NOs	1,141	2,547	
-FISHERIES & OTHERS	-	-	20,095	
-PUBLIC FACILITIES	-	-	384	
*.RESETTLEMENTS & OTHERS	-	-	3,787	
TOTAL			37,560	

Table II-5

SUMMARY OF THE PROJECT COST

UNIT : US $ MILLION
US $ 1.00=780.00(APPRAISAL)
US $ 1.00=740.00(APR.7.88)

	A APPRAISAL	B ACTUAL	B A DIFFERENCE
TOTAL PROJECT COST	167.20	212.43	45.23
A.PREPARATORY WORKS	4.42	5.44	1.02
B.CIVIL WORKS	64.63	75.34	10.71
1.BUILDING PIT	3.32	1.66	(1.66)
2.EARTH WORKS	21.46	30.21	8.75
3.PROTECTION WORKS	11.05	15.79	4.74
4.BARRAGE	19.44	20.38	0.94
5.NAVIGATION LOCK	4.44	3.47	(0.97)
6.DISCHARGE SLUICE	2.16	1.61	(0.55)
7.OPERATION BUILDING	0.27	0.22	(0.05)
8.ROAD WORKS	1.77	1.22	(0.55)
9.VIADUCTS	0.72	0.78	0.06
C.GATE & STRUCTURAL STEEL	5.53	5.48	(0.05)
D.MECHANICAL WORKS	5.43	5.55	0.12
E.ELECTRICAL WORKS	1.18	1.19	0.01
F.CONTINGENCY	44.00	* 2.81	(41.19)
G.DRAINAGE SYSTEM & APPURTENANT WORKS		31.81	31.81
H.FLOOD FORECASTING & WATER MANAGEMENT	-	6.36	6.36
I.LAND ACQUISITION & COMPENSATION	19.91	37.56	17.65
J.PROJECT MANAGEMENT	14.34	31.65	17.31
K.CUSTOM DUTIES & TAXES	7.76	9.24	1.48

* PRICE ESCALATION ONLY

Table II-6

ANNUAL PROJECT COST

1 $ = 740.0 (84.4.7

WORKS	TOTAL IN MILLION WON			TOTAL IN MILLION US $			% OF TOTAL	% OF FOREIGN	TOTAL COST IN US MILLION					
	LOCAL	FOREIGN	TOTAL	LOCAL	FOREIGN	TOTAL			83	84	85	86	87	88
TOTAL PROJECT COST	121,870	35,323	157,199	164.70	47.73	212.43	100.00	22.47	5.19	30.34	52.39	58.01	59.53	6.97
1.CONSTRUCTION COST	73,317	32,666	105,983	99.08	44.14	143.22	67.42	30.82	1.18	18.81	32.93	38.86	45.34	6.10
A.BARRAGE & RECLAMATION	68,611	32,666	101,277	92.72	44.14	136.86	64.43	32.25	1.18	18.81	32.86	34.41	43.51	6.09
PREPARATORY WORKS	2,539	1,488	4,027	3.43	2.01	5.44	2.56	36.95	0.57	1.79	1.17	0.53	1.26	0.12
BUILDING PIT	779	451	1,230	1.05	0.61	1.66	0.78	36.75		1.18	0.23	0.21	0.04	
EARTH WORKS	14,157	8,199	22,356	19.13	11.08	30.21	14.23	36.68	0.16	6.17	8.68	8.84	5.78	0.58
PROTECTION WORKS	7,398	4,285	11,683	10.00	5.79	15.79	7.43	36.67	-	1.06	1.91	5.51	5.45	1.86
BARRAGE	6,438	8,643	15,081	8.70	11.68	20.38	9.59	57.31	-	4.58	9.97	4.62	1.07	0.14
NAVIGATION LOCK	819	1,747	2,566	1.11	2.36	3.47	1.64	68.01	-	1.07	0.06	1.48	0.63	0.23
DISCHARGE SLUICE	379	814	1,193	0.51	1.10	1.61	0.76	68.32	-	-	0.70	0.28	0.52	0.11
OPERATION BUILDING	104	59	163	0.14	0.08	0.22	0.10	36.36	-			0.11	0.11	
ROAD WORKS	573	333	906	0.77	0.45	1.22	0.57	36.89	-				1.21	0.01
VIADUCTS	362	215	577	0.49	0.29	0.78	0.38	37.18					0.77	0.01
GATE & STRUCTURAL STEEL	2,322	1,732	4,054	3.14	2.34	5.48	2.58	42.70	-	0.79	2.48	1.89	0.32	
MECHANICAL WORKS	1,860	2,250	4,110	2.51	3.04	5.55	2.61	54.77	-		3.52	1.63	0.40	
ELECTRICAL WORKS	391	489	880	0.53	0.66	1.19	0.56	55.46	0.05	0.01	0.09	0.57	0.47	
DRAINAGE FACILITIES	6,349	651	7,000	8.58	0.88	9.46	4.45	9.30	-	-	-	1.94	7.06	0.46
LANDSCAPING	3,477	281	3,758	4.70	0.39	5.09	2.39	7.48	-	-			4.85	0.23
ENCALATION	1,328	748	2,076	1.80	1.01	2.81	1.32	35.94	-		0.60	1.06	0.97	0.18
AUXILIARY WORKS	12,496	281	12,777	16.89	0.38	17.27	8.13	2.20	0.36	0.07	1.00	3.78	10.42	1.64
CUSTOM DUTIES & TAXES	6,840	-	6,840	9.24	-	9.24	4.35	0.00	0.04	2.09	2.45	1.96	2.18	0.52
B.FLOOD FORECASTING,WATER MANAGEMENT & OTHERS	4,706		4,706	6.36		6.36	2.99	0.00	-		0.07	4.45	1.83	0.01
2.COMPENSATION COST	27,791		27,791	37.56		37.56	17.68	0.00	0.06	7.79	13.48	9.58	5.93	0.72
LAND ACQUISITION	7,953	-	7,953	10.75	-	10.75	5.06	0.00	-	3.52	0.89	3.34	2.70	0.30
COMPENSATION	19,838	-	19,838	26.81	-	26.81	12.62	0.00	0.06	4.27	12.59	6.24	3.23	0.42
3.PROJECT MANAGEMENT COST	20,768	2,657	23,425	28.06	3.59	31.65	14.90	11.34	3.95	3.71	5.98	9.57	8.26	0.14
ENVIRONMENTAL MANAGEMENT	545	296	841	0.74	0.40	1.14	0.54	35.09	0.16	0.34	0.28	0.23	0.13	
PROJECT SUPERVISION	506	2,028	2,534	0.68	2.88	3.56	1.68	80.90	0.53	0.54	0.70	0.91	0.84	0.04
MICRO COMPUTER	-	67	67	-	0.09	0.09	0.04	100.00	-		0.09	-		
FEE & OTHERS	2,851	266	3,117	3.85	0.22	4.07	1.91	5.41	2.46	0.05	0.13	1.08	0.24	0.11
I . D . C	11,730	-	11,730	15.85		15.85	7.46	0.00	0.11	1.53	3.29	5.70	5.22	
ADMINISTRATION	5,136	-	5,136	6.94	-	6.94	3.27	0.00	0.69	1.28	1.49	1.65	1.83	

Table II-7

ANNUAL DISBURSEMENT OF THE LOAN

UNIT: US $ MILLION

YEARS	APPRAISAL		ACTUAL	
	AMOUNT	CUMULATIVE	AMOUNT	CUMULATIVE
TOTAL	73.50		47.73	
1984	13.50	13.50	8.05	8.05
1985	14.10	27.60	16.24	24.29
1986	19.60	47.20	17.42	41.71
1987	19.30	66.50	5.89	47.60
1988	7.00	73.50	0.13	47.73

Table II-8

REALLOCATION OF THE LOAN

UNIT : US $ THOUSAND

	ORIGINAL ALLOCATION	ACTUAL DISBURSEMENT	BALANCED UNDISBURSED
TOTAL	73,500	47,731	25,769
1.CIVIL WORKS & MATERIALS FOR PART A	57,117	44,137	12,980
A) MOBILIZATION	5,000	4,995	5
B) PROGRESS PAYMENT	52,117	39,142	12,975
2.EQUIPMENT & MATERIALS FOR PART B	200	94	106
3.CONSULTANT'S SERVICES & TRAINING	5,000	3,276	1,724
4.SPECIAL ACCOUNT	-	-	0
5.FEE	183	183	0
6.UNALLOCATED	11,000	-	11,000
7.LOSS ON FOREIGN CURRENCY TRANSACTION	-	41	(41)

. DEMAND FOR M & I WATER

UNIT : 10 e 8 3 / YEAR

	DIVISION	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02
	GRAND TOTAL	669.1	677.5	726.3	792.9	858.2	[illegible]	1,037.1	1,099.7	1,162.[illegible]	1,224.8	1,287.6	1,344.5	1,401.5	1,458.6	1,515.6	1,572.5	1,629.3	1,686.[illegible]	1,742.7	1,800.4	1,856.2	1,913.2
	MAIN STEM	625.9	629.5	678.6	707.2	766.3	[illegible]	925.3	979.3	1,032.9	1,086.7	1,140.2	1,193.6	1,247.2	1,300.8	1,354.4	1,408.1	1,461.7	1,515.4	1,569.0	1,622.6	1,676.3	1,729.9
	TRIBUTRIES	43.2	48.0	53.7	85.7	91.9	102.6	111.8	120.4	129.4	136.1	147.2	212.9	254.[illegible]	255.6	277.0	298.4	304.9	313.1	325.3	336.8	335.6	354.0
IOF	TOTAL	10.6	12.2	13.9	14.7	15.2	16.9	18.3	19.6	21.1	22.4	23.8	25.0	26.2	27.4	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.3
	MAIN STEM																						
	TRIBUTRIES	10.6	12.2	13.9	14.7	15.2	16.9	18.3	19.6	21.1	22.4	23.8	25.0	26.2	27.4	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.3
UPPER	TOTAL	8.8	9.5	10.1	11.4	11.9	13.7	14.8	15.9	16.9	18.0	19.1	20.7	22.3	23.9	25.5	27.0	28.6	30.[illegible]	32.4	34.2	36.0	37.8
	MAIN STEM																						
	TRIBUTRIES	8.8	9.5	10.5	11.4	11.9	13.7	14.8	15.9	16.9	18.0	19.1	20.7	22.3	23.9	25.5	27.0	28.6	30.[illegible]	32.4	34.2	36.0	37.8
MIDDLE	TOTAL	153.0	155.9	161.5	205.4	237.5	258.2	279.2	300.2	321.2	342.2	363.1	381.9	400.7	419.6	438.4	457.2	469.8	482.5	495.3	508.0	520.7	533.4
	MAIN STEM	149.8	152.4	157.0	173.7	201.4	219.1	236.6	254.5	272.1	289.9	307.4	266.9	270.7	274.6	278.6	282.5	294.0	302.1	310.3	318.[illegible]	326.6	334.8
	TRIBUTRIES	3.2	3.5	4.5	31.7	36.1	39.1	42.6	45.7	49.1	52.3	55.7	115.0	130.0	144.8	159.8	174.9	175.8	180.4	185.0	189.6	194.1	198.6
MIDDLE LOWER	TOTAL	17.9	19.8	21.0	23.1	23.7	27.3	30.0	32.7	35.4	38.1	40.8	43.9	47.0	50.2	53.3	56.4	58.6	60.7	[illegible]	66.1	67.2	69.4
	MAIN STEM																						
	TRIBUTRIES	17.9	19.8	21.0	23.1	23.7	27.3	30.0	32.7	35.4	38.1	40.8	43.9	47.0	50.2	53.3	56.4	58.6	60.7	62.9	66.1	67.2	69.4
LOWER	TOTAL	35.5	36.0	38.5	40.2	55.5	75.4	82.9	90.0	97.0	104.0	111.0	118.2	125.3	132.4	139.6	146.7	155.1	163.4	171.8	180.2	188.6	196.9
	MAIN STEM	32.8	33.0	34.7	35.4	50.5	70.[illegible]	76.8	83.5	90.1	96.7	103.2	109.9	116.5	123.1	129.8	136.4	144.4	152.2	160.1	168.[illegible]	176.[illegible]	[illegible]
	TRIBUTRIES	2.7	3.0	3.8	4.8	5.0	5.6	6.1	6.5	6.9	7.3	7.8	8.3	8.8	9.3	9.8	10.3	10.7	11.2	11.6	12.1	12.5	12.9
ESTUARY	TOTAL	443.3	443.3	482.9	[illegible]	514.4	[illegible]	[illegible]	[illegible]	670.7	[illegible]	[illegible]	[illegible]	780.8	805.1	830.2	855.4	880.0	916.5	946.9	977.3	1,007.9	1,038.4
	MAIN STEM	443.3	468.3	482.9	498.1	514.4	562.4	611.9	661.3	670.7	700.1	729.6	758.8	780.8	805.1	830.2	855.4	880.0	916.5	946.9	977.3	1,007.9	1,038.4
	TRIBUTRIES																						

Table II-9

MUNICIPALITIES & CITIES	POPULATION FORECAST (1000 PERSONS)					% POPULATION SERVED					PER CAPITA PRODUCTION LCD					TOTAL DEMAND (000 CMD				
	'85	'86	'91	'96	'2001	'85	'86	'91	'96	'2001	'85	'86	'91	'96	'2001	'85	'86	'91	'96	'2001
AN DONG (SI)	114	120	138	152	163	89.2	90.0	90.0	92.0	95.0	222	250	300	320	350	23.59	27.00	37.26	44.75	54.20
YEONG JU (SI)	85	87	97	104	111	84.[illegible]	85.0	90.0	94.0	95.0	188	200	250	300	320	15.57	16.79	21.83	29.33	33.74
YEONG YANG	14	14	15	16	17	66.2	67.0	70.0	70.0	85.0	162	162	165	200	220	1.50	1.52	1.73	2.24	3.18
CHEONG SONG	9	9	10	11	12	45.[illegible]	47.0	60.0	70.0	85.0	199	200	200	210	220	0.82	0.85	1.20	1.62	2.26
TOP 4 MUNICIPALITIES	222	230	260	283	303											39.48	44.16	62.02	77.95	93.36
GIN CHEON (SI)	77	79	88	95	101	77.0	77.0	80.0	85.0	95.0	230	240	280	300	300	15.64	14.68	19.71	24.23	28.79
JEON CHUN(SI)	57	59	66	78	83	67.8	69.0	80.0	90.0	95.0	169	180	200	240	300	6.53	7.22	10.56	16.85	23.66
SANG JU (SI)	59	61	68	73	78	54.1	65.0	75.0	85.0	90.0	125	160	180	240	300	3.99	6.34	9.18	14.89	21.06
EUI SEONG	22	23	25	27	28	81.5	82.0	85.0	85.0	95.0	133	150	180	240	300	2.38	2.83	3.83	5.51	7.98
YE CHEON	25	26	28	30	32	51.6	52.0	60.0	70.0	85.0	214	214	220	230	240	2.76	2.89	3.70	4.83	6.53
AN GEI	9	9	10	11	12	62.1	63.0	70.0	75.0	85.0	136	160	180	200	240	0.76	0.91	1.26	1.65	2.45
GUN WI	11	11	13	15	17	42.2	49.0	60.0	75.0	85.0	180	190	200	240	240	0.81	1.02	1.56	2.70	3.47
UPPER 7 MUNICIPALITIES	260	268	298	329	351											30.54	35.82	49.74	70.61	93.92
DAE GU (SI)	2,031	2,151	2,506	2,757	2,964	94.0	95.0	97.0	100.0	100.0	280	280	340	380	400	534.56	572.17	826.48	1,047.66	1,185.60
GU MI (SI)	142	150	175	193	207	81.6	82.0	85.0	90.0	100.0	250	250	300	350	400	28.97	30.75	44.63	60.68	82.80
YEONG CHEON (SI)	53	55	61	66	70	75.1	85.0	90.0	95.0	95.0	225	225	250	300	300	8.96	10.52	13.73	18.81	19.95
MAE GWAN	28	29	31	33	35	81.4	82.0	85.0	90.0	95.0	171	180	200	220	240	3.90	4.28	5.27	6.53	7.98
GYEONG SAN	43	44	48	51	54	85.3	86.0	86.0	90.0	95.0	134	160	180	200	240	4.91	6.05	7.43	9.18	12.11
MIDDLE 5 MUNICIPALITIES	2,297	2,429	2,821	3,100	3,330											581.30	623.77	897.53	1,142.96	1,308.04
JIN JU (SI)	227	260	320	370	413	92.0	92.0	95.0	100.0	100.0	230	250	300	340	360	48.07	59.80	91.20	125.80	148.68
GEO CHANG	39	40	43	46	48	69.0	69.0	75.0	80.0	85.0	164	170	180	240	240	4.41	4.69	5.91	7.85	9.79
GA YA	15	15	17	18	19	45.0	50.0	70.0	75.0	85.0	206	210	210	220	240	1.39	1.58	2.50	2.97	3.88
EUI RYEONG	12	12	13	14	15	68.0	69.0	75.0	85.0	85.0	148	150	180	220	240	1.21	1.24	1.76	2.62	3.06
HAP CHEON	14	14	15	16	17	62.0	66.0	75.0	80.0	85.0	152	160	160	180	240	1.32	1.48	1.80	2.30	3.47
SAN CHEONG	11	12	13	15	16	55.0	55.0	60.0	70.0	85.0	97	120	160	190	240	0.60	0.77	1.26	2.10	3.26
HAP RYEONG	12	12	13	14	15	65.9	66.0	75.0	85.0	85.0	188	190	210	240	240	1.49	1.50	2.05	2.86	3.86
MIDDLE LOWER 7 MUNICIPALITIES	330	365	435	493	543											58.41	71.08	106.45	147.38	175.70
NA SAN (SI)	440	466	543	597	642	86.0	87.0	90.0	95.0	100.0	260	260	300	350	400	98.38	105.41	146.01	198.50	256.80
CHANG WON (SI)	180	181	211	232	249	68.0	80.0	95.0	95.0	100.0	250	250	300	350	400	30.60	36.20	60.14	77.14	99.60
JIN HAE (SI)	130	138	161	177	190	86.0	86.0	90.0	95.0	95.0	220	220	250	280	330	24.68	26.11	36.25	47.08	59.57

GIN HAI (SI)	78	80	89	96	102	65.0	75.0	75.0	85.0	95.0	136	136	180	220	240	6.90	8.16	12.02	17.95	23.26
HIL YANG	51	52	56	60	63	60.0	65.0	80.0	85.0	90.0	254	254	260	300	300	7.77	8.59	11.65	15.30	17.01
JIN YEONG	22	23	25	27	28	54.0	60.0	60.0	65.0	85.0	200	210	220	220	240	2.47	2.98	4.80	5.05	5.71
CHANG NYONG	21	22	24	26	27	56.0	60.0	70.0	80.0	85.0	127	180	200	240	240	1.49	2.38	3.56	4.99	5.51
CHEONG DO	21	22	24	26	27	47.6	46.0	65.0	75.0	85.0	166	180	200	240	240	1.66	1.90	3.12	4.68	5.51
YANG SAN	27	28	30	32	34	60.0	60.0	70.0	80.0	85.0	173	180	180	200	240	2.80	3.02	3.76	5.12	6.94
CHEONG JIN	17	22	23	25	26	38.0	38.0	65.0	65.0	95.0	149	150	160	180	220	0.96	1.25	1.66	2.69	5.02
HA NAM	14	15	17	19	21	38.0	40.0	60.0	75.0	80.0	130	140	160	180	240	0.69	0.90	1.77	2.57	4.05
HAN GEUN	10	11	13	15	17	60.0	60.0	75.0	80.0	95.0	155	160	170	180	200	0.93	1.16	1.69	2.16	3.23
LOWER 12 MUNICIPALITIES	1,011	1,060	1,216	1,330	1,424											179.26	197.98	286.37	385.23	492.17
EU SAN (SI)	3,517	3,658	4,207	4,628	4,975	93.0	94.0	98.0	100.0	100.0	300	320	340	360	400	981.24	1,100.33	1,401.77	1,666.88	1,990.00
UL SAN (SI)	580	614	715	787	846	85.0	85.0	90.0	95.0	100.0	250	250	300	350	400	123.25	130.48	193.05	261.68	338.40
ESTUARY 2 MUNICIPALITIES	4,097	4,272	4,922	5,415	5,821											1,104.49	1,230.80	1,594.82	1,927.76	2,328.40
TOTAL 37 MUNICIPALITIES	8,217	8,624	9,952	10,950	11,772											1,494	2,204	2,997	3,750	4,692

Table II-11

SUMMARY OF THE ESTIMATED LAND SALES

EXCHANGE RATE : 1 $=740.00 ('88.4.7)

	AREA	ESTIMATED PRICES		REMARKS
	(1000 M^2)	MILLION WON	MILLION US $	
TOTAL	2,358.8	223,763	302.38	
*.LANDS FOR PUBLIC UTILITIES (FOR SEWAGE TREATMENT PLANT, SUBWAY TERMINAL)	497.9	32,824	44.36	
*.INDUSTRIAL AREAS	1,143.5	101,671	137.39	
*.COMMERCIAL AREAS	429.8	46,981	63.49	
*.RESIDENTIAL AREAS	287.6	42,287	57.14	

Table II-12

KOWACO: FINANCIAL STATEMENT
(W Million)

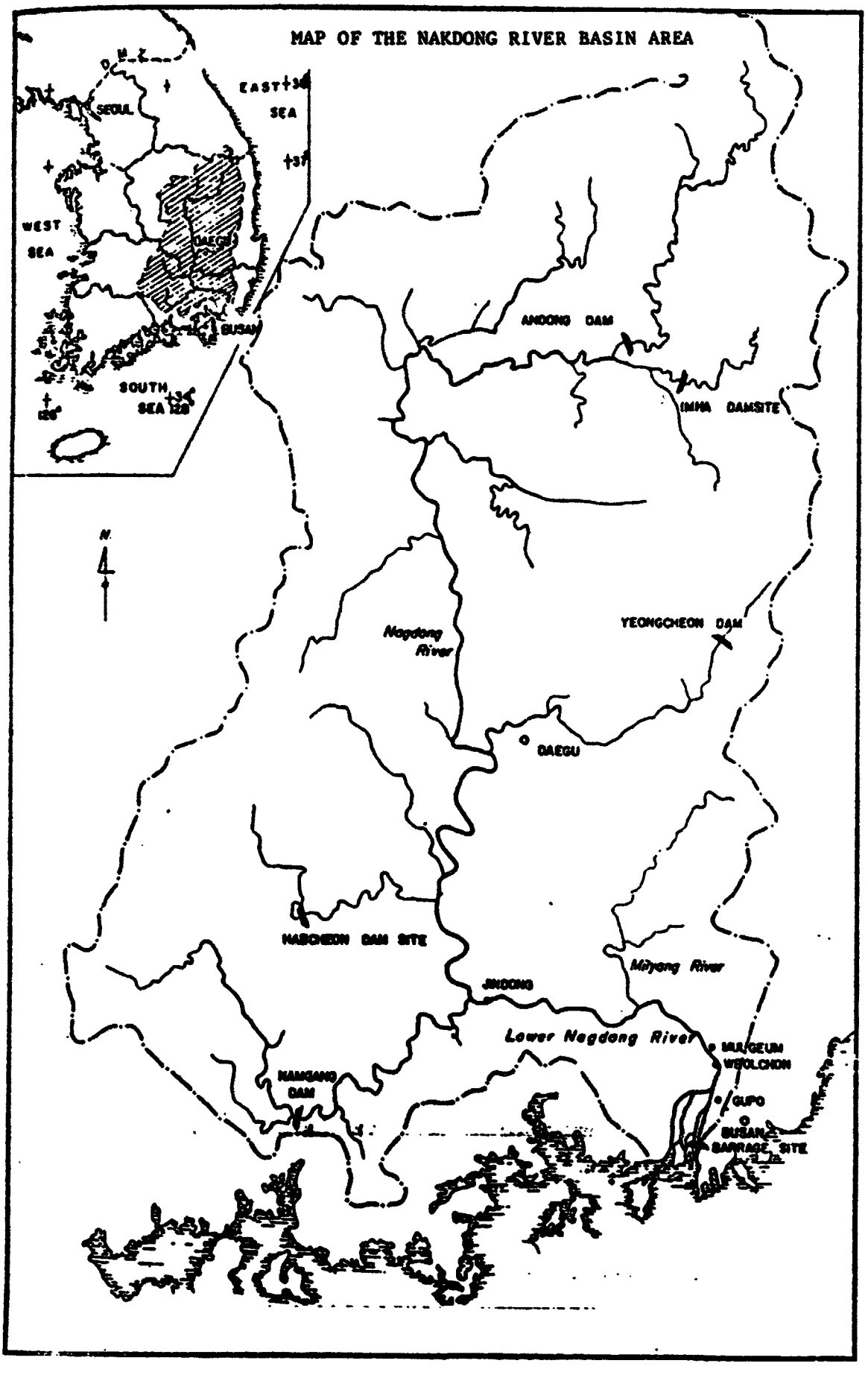
	1983	1984	1985	1986	1987	1988
Operating revenues	96,987	156,521	297,856	318,190	437,034	588,051
Less: Operating expenses (including Administration)	90,461	144,281	270,648	282,891	359,337	472,703
Operating income (loss)	6,526	12,240	27,208	35,299	77,697	115,348
Nonoperating income (net)	2,793	4,903	-150	-10,602	-25,960	-16,183
Net income	9,319	17,143	27,058	24,697	51,737	99,165
% operating ratio	93.3	92.2	90.9	88.9	82.2	80.4
Net income as percentage of equity	1.63	2.62	3.78	3.24	6.37	10.50
Current assets	116,422	155,509	196,399	239,852	325,495	448,615
Other assets	32,243	27,471	34,600	181,663	111,434	128,000
Net fixed assets	909,466	983,277	1,164,002	1,160,700	1,262,569	1,242,533
Total Assets	1,058,131	1,166,257	1,395,001	1,582,215	1,699,497	1,819,148
Current liabilities	88,104	137,326	148,156	212,577	241,457	279,351
Long-term debt	387,318	362,908	520,998	595,025	631,242	576,548
Reserves	10,420	11,757	10,350	13,117	14,274	19,066
Equity	572,289	654,266	715,497	761,496	812,524	944,183
Total Equity and Liabilities	1,058,131	1,166,257	1,395,001	1,582,215	1,699,497	1,819,148
Current ratio	1.32	1.13	1.33	1.13	1.35	1.61
% Debt/(debt + equity)	40.4	35.7	42.1	43.9	43.7	37.9

KOWACO: DIVISION, REVENUES AND EXPENSES
(W Million)

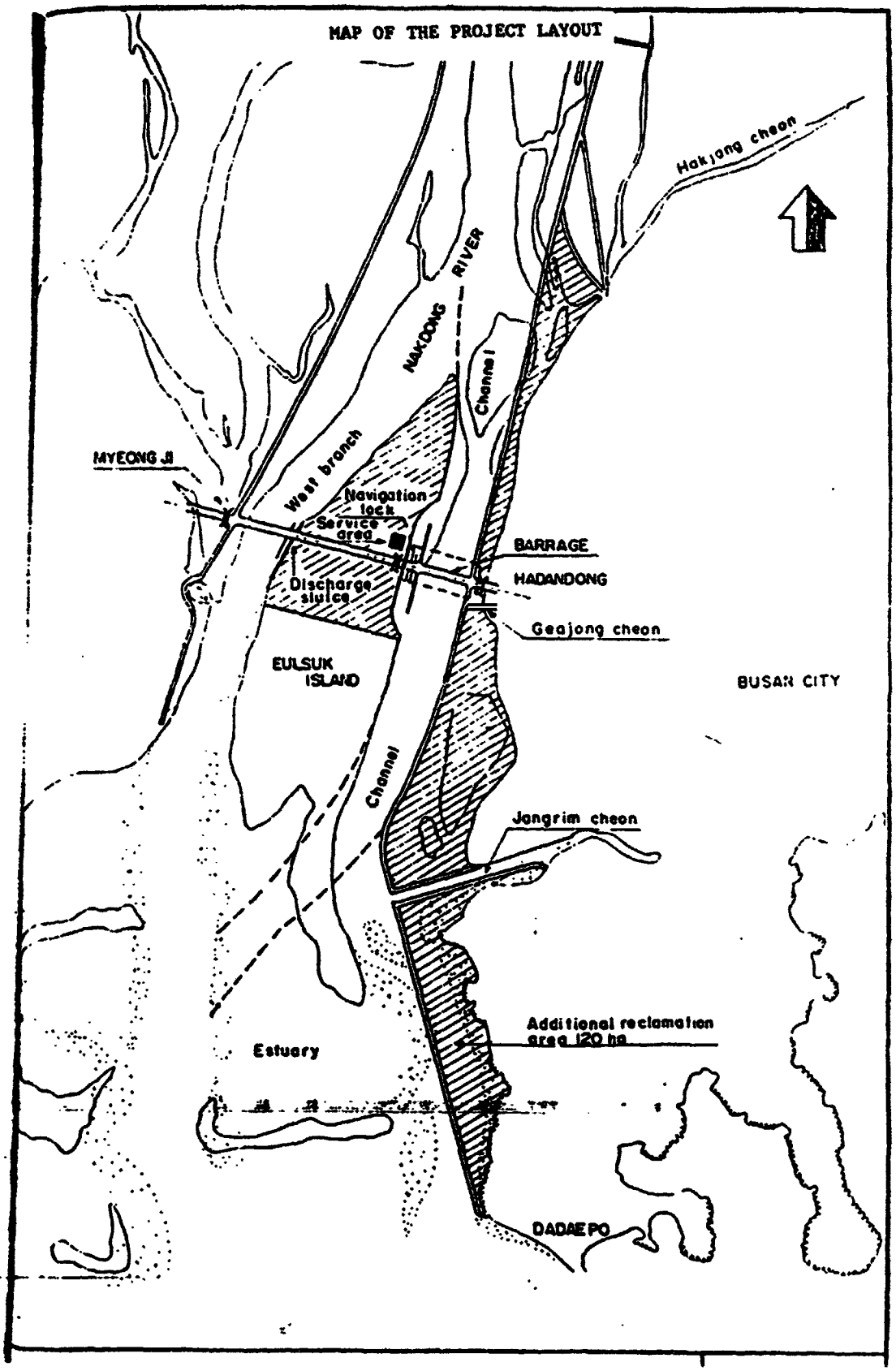
	1993			1994			1995			1996			1997			1998		
	Revenues	Expenses	Gross profit	Revenues	Expenses	Gross profit	Revenues	Expenses	Gross profit	Revenues	Expenses	Gross profit	Revenues	Expenses	Gross profit	Revenues	Expenses	Gross profit
Industrial sites and new towns	45,215	44,486	729	49,038	48,188	850	120,967	118,791	2,176	122,142	99,916	22,226	163,752	129,924	33,828	305,345	212,419	92,926
Water supply	32,991	26,025	6,966	35,513	27,835	7,678	37,451	26,877	10,574	40,786	31,556	9,230	42,007	34,028	8,069	49,836	40,506	9,330
Dams	18,120	15,312	2,808	71,068	63,427	7,641	133,752	115,116	18,646	149,682	140,250	9,432	224,017	181,698	42,319	221,727	200,392	21,335
Other revenues/ expenses	661	641	20	902	872	30	5,676	5,656	20	5,580	5,571	9	7,168	7,156	12	11,143	11,133	10
Total	96,987	86,464	10,523	156,521	140,322	16,199	297,856	266,440	31,416	318,190	277,293	40,897	437,034	352,806	84,228	588,051	464,450	123,601
General administration		3,997	3,997		3,959	3,959		4,208	4,208		5,598	-5,598		6,532	6,532		8,253	8,253
Other income	5,116	660	4,456	8,378	1,382	6,994	11,291	7,275	4,016	13,902	18,963	-5,061	11,560	26,609	15,049	48,917	45,917	3,000
Income taxes		1,661	1,661		2,092	2,092		4,166	4,166		5,542	-5,542		10,911	10,911		19,183	19,183
Net income			9,318			17,143			27,058			24,696			51,737			99,165

Table II-13

Map II-1

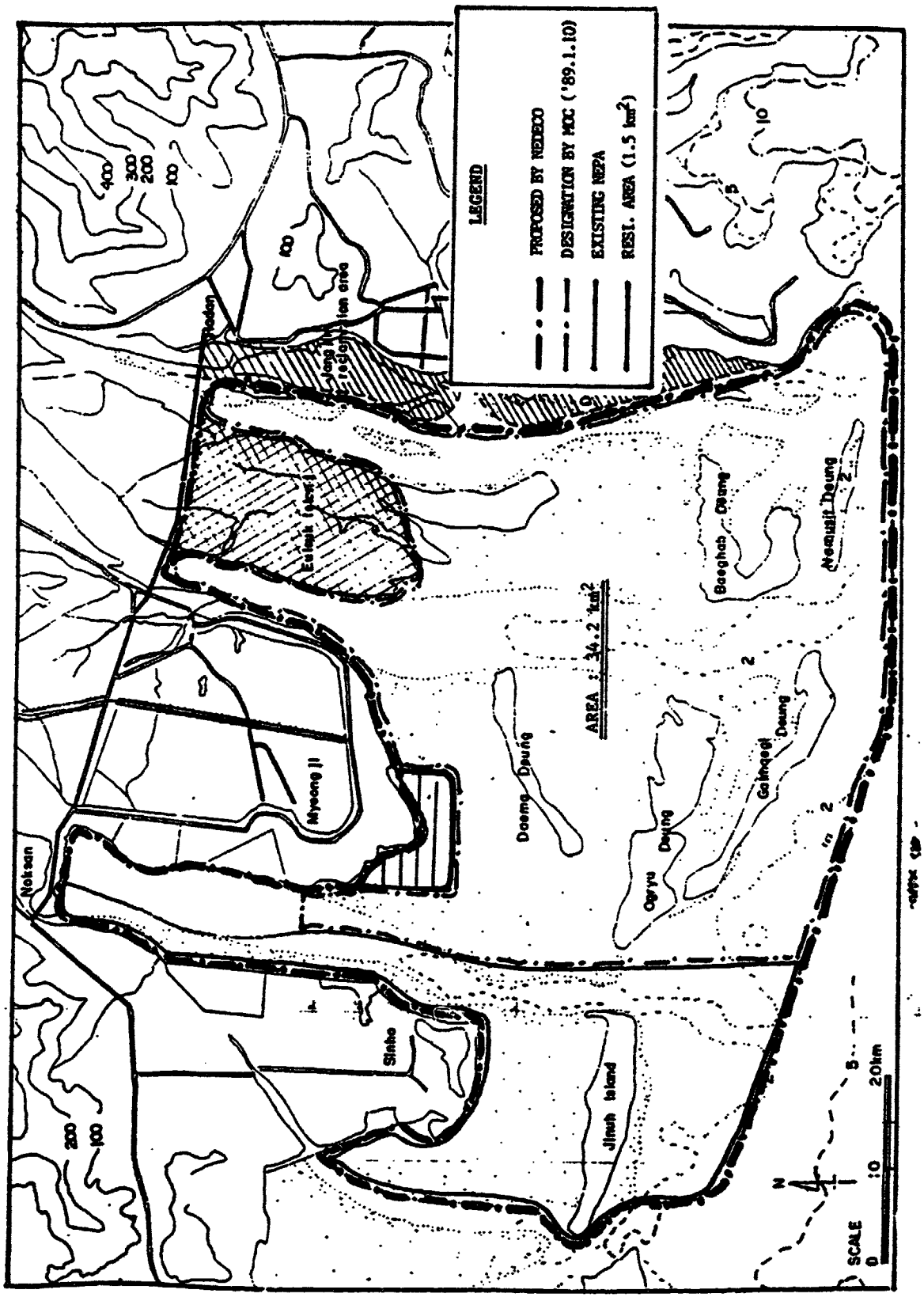

MAP OF THE NAKDONG RIVER BASIN AREA
SEOUL
EAST SEA
WEST SEA
DAEGU
BUSAN
SOUTH SEA
ANDONG DAM
IMHA DAMSITE
N
Nagdong River
YEONGCHEON DAM
DAEGU
HAPCHEON DAM SITE
Milyang River
JINJOONG
Lower Nagdong River
MULGEUM
WEOLCHON
NAMGANG DAM
GUPO
BUSAN BARRAGE SITE

Map II-2


MAP OF THE PROJECT LAYOUT
Hakjong cheon
NAKDONG RIVER
Channel
West branch
MYEONG JI
Navigation lock
Service area
BARRAGE
HADANDONG
Discharge sluice
Geajong cheon
EULSUK ISLAND
BUSAN CITY
Channel
Jangrim cheon
Additional reclamation area 120 ha
Estuary
DADAE PO

Map II-3

DESIGNATION OF THE NEPA



PROJECT COMPLETION REPORT

KOREA
SECOND WATER SUPPLY PROJECT
(LOAN 2350-KO)

Part III: STATISTICAL INFORMATION

Table 1. Related Bank Loans

Loan Title	Purpose	Year of Approval	Status	Comments
Chungju Multipurpose Project (Ln. 1666-KO)	To meet various water needs in the Han Basin.	1979	Completed	Financed detailed engineering of Nakdong Barrage, which was constructed under Ln. 2350-KO.
Water Supply I (Ln. 2072-KO)	To expand water supply in five cities (Daegu, Gwangju, Masan, Changweon, Jinhae) and strengthen sector institutions.	1982	Completed	Main project objectives achieved; see PCR of 2/27/89.
Metropolitan Water Supply Project (Ln. 2491-KO)	To expand water supply for Seoul Metropolitan Region, study tariff policies and Region's sector organizations, and improve ISWACO's financial performance.	1985	Ongoing	Implementation is satisfactory. Loan closing expected by 6/30/90, 6 months later than planned to allow for completion of disbursement.
Namgang and Taegu Water Supply Project (Ln. 2615-KO)	To expand water supply available for Kyeongnam Province and the City of Taegu and to improve sector coordination.	1985	Ongoing	Implementation is satisfactory. Loan closing expected by 6/30/90 as planned.

Table 2. Project Timetable

Item	Date Planned	Date Revised	Date Actual
Identification	-	-	12/82
Preparation	-	-	02/83
Appraisal Mission	04/83	-	04/25/83- 05/13/83
Loan Negotiations	11/10/83	-	09/06/83 09/10/83
Board Approval	01/17/84	12/15/83	10/18/83
Loan Signature	-	-	10/21/83
Loan Effectiveness	04/84	-	01/11/84
Project Completion	06/30/88	-	06/30/89
Loan Closing	06/30/89	-	06/30/89

Issues Raised during the Project Cycle

At project identification, the main issues were as follows: (a) the environmental impact of the barrage design, which had to be approved by the Office of Environment (OOE); (b) water pricing policy; (c) the need for advance contracting of works; (d) the still unsatisfactory financial performance of the Pusan Water Bureau; and (e) the inclusion of leak detection and institutional improvement programs under the project.

During project preparation, discussion continued to center around the project's environmental impact and the need to improve cost recovery by raising tariffs, as well as (a) the justification of constructing both the barrage and the Hapcheon Dam, which were previously regarded as alternative solutions to the salinity problem; (b) whether or not to include the Pusan works under the Bank-supported project; and (c) the inclusion of financial performance covenants for KOWACO.

At appraisal, it was resolved that (a) the Hapcheon Dam was justified on the basis of projected water demand but would not solve the salinity problem; (b) although close Bank involvement in implementation of the Pusan works was not needed, a covenant would be included in the Loan Agreement that these works would be completed by December 31, 1987; (c) letters of understanding on payment for water usage between KOWACO and the chief project beneficiaries, Pusan and Ulsan/Onsan, would be provided as a condition of Board presentation; (d) progress

in implementing the First Water Supply Project would be improved; and (e) to minimize changes in the estuarine ecosystem due to the operation of the barrage and closure of the right river branch, safeguards were incorporated in the barrage design, controls were placed on construction operations, an Environmental Impact Assessment (EIA) of the Barrage was approved by the Office of Environment, which would monitor the projects's environmental impact during implementation and review a separate EIA prepared for the use of reclaimed land (which had been reduced from 600 ha to 190 ha), and, to protect the wetlands, a zone in the estuary would be made a Natural Environment Preservation Area (to prohibit land reclamation near the mud flats, which was the main threat to the bird sanctuary), as a condition of the Loan Agreement.

During negotiations, the Government and the Bank discussed and agreed on a number of actions, the most relevant being: (a) to reduce the proposed loan amount from US$120 million to US$87.5 million due to lower than expected bids; (b) to carry out measures aimed at accelerating progress on the previous project; and (c) to finance the Pusan complementary works under funding arrangements found satisfactory.

During project supervision, the key issues were: (a) results of studies on water and dams tariffs (carried out under Loan 2491-KO), that would influence the financial performance of water supply entities under the project; (b) the lack of progress on the Janglim interceptor sewer; (c) plans of Pusan City to develop part of the ecologically-important estuary area for industrial development and the urgent need to protect this area under law; and (d) problems in KOWACO's financial performance as a result of the 1988 drought.

Table 3. Loan Disbursements

Cumulative Estimated and Actual Disbursements
(US$ million)

	FY84	FY85	FY86	FY87	FY88	FY89
Appraisal Estimate	8.5	21.1	39.4	62.2	76.5	78.5
Actual	6.5	23.3	41.5	50.0	50.7	51.3
Actual as % of Estimate	76	110	105	80	66	65

Date of Final Disbursement: March 23, 1989

Cancellations: Cancellations totalled US$27.2 million due to savings resulting from an increase in the exchange rate of the won from 780 to 880 to the US dollar, low inflation in the country, and highly competitive bidding for equipment and consultant services. The timing and amounts of the cancellations were as follows:

Date	Amount (US$)
June 30, 1986	13,500,000.00
April 20, 1987	1,200,000.00
August 21, 1987	12,210,000.00
June 6, 1988	58,666.82
October 18, 1989	229,089.18
October 26, 1989	13,692.37
TOTAL	27,211,448.37

Table 4. Project Implementation

A comparison of the planned and actual timetable for the various aspects of project construction is given in Figure III-1 of Part II of the report. Actual construction of the barrage took two months less than expected, and the barrage began operations in September 1987, more than one year ahead of schedule. The leak detection and institutional development programs were completed in September 1988, about two years later than expected, due to the expansion of the program to cover more cities (including five cities in the First Water Supply Project), delayed selection of consultants, staffing and funding constraints affecting the leak detection program, and procurement of additional leak detection equipment.

Monitoring indicators used to assess the performance of KOWACO's Dams and Water Divisions are given below.

A. KOWACO Water Division, 1988[1]

	Estimated	Actual	% Actual/Estimate
DEMAND			
Raw water sold (million mt)	1,176	1,164	99%
Treated water sold (million mt)	54	190	351%
Total water sold (million mt)	1,230	1,354	110%
Water production (million mt)	1,295	1,425	110%
MANAGEMENT			
Accounts receivable (days)	37	34	92%
Employees (number)	670	957	381%
FINANCIAL			
Raw water tariff (W/ton)	52.2	40.4	77%
Treated water tariff (W/ton)	59.0	87.5	48%
Total average tariff (W/ton)	55.3	46.9	85%
Working ratio (%)	59.0	76.0	128%
Contribution to investment (%)	57.0	10.0	NA
Rate of return (%)	5.0	3.0	60%
Debt service ratio	7.0	1.7	24%
Debt on debt plus equity (%)	19.0	18.0	95%

[1] Projections were made up to 1990; data for 1988 are shown here to indicate actuals. However, low water flows during one of the worst droughts in the century (and a related reduction in power sales) hurt KOWACO's financial performance in 1988, reducing the rate of return on both the water and dams operations to 3% (rather than the 5% covenanted). This problem cannot be addressed by tariff increases. KOWACO's financial performance will be normalized as soon as water flows (and power generation) return to less critical levels.

B. KOWACO Dams Division, 1988

	Estimated	Actual	% Actual/Estimate
DEMAND			
Municipal and Industrial water sold (million tons)	2,158	1,706	79%
Power sales (GWh)	1,747	1,145 [2]	65%
Irrigated land (ha) [3]	8,500	2,094	25%
MANAGEMENT			
Accounts receivable (days)	29	37	128%
Number of Employees	555	539	97%
FINANCIAL			
Average Rates:			
Mun. & ind. water (W/ton)	7.8	6.0	77%
Power (W/kWh)	43.7	37.3	85%
Working ratio (%)	14.9	25.9	174%
Contribution to investment (%)	80.2	-26.7	NA
Rate of return (%)	5.0	3.0	60%
Debt service ratio	1.5	0.6	40%
Debt on debt plus equity	18.0	37.0	205%

[2]Due to one of the worst droughts in this century.

[3]Government decided not to bill farmers for irrigation water taken from rivers.

Table 5. Project Costs and Financing

A. Project Costs

Detailed comparisons of the estimated and actual costs of the barrage are given in Part II, Tables III-4 and III-5. The completed barrage cost US$212.43 million, or US$45.23 million more than expected, due to higher than expected land compensation costs and additional works carried out under the project, including establishment of a flood forecasting system, increased land reclamation (by 140 ha), full development (water, roads, sewerage, etc.) of the land reclaimed, and facilities for operation and maintenance of the barrage. The leak detection and computerization programs cost about US$5.3 million or two thirds of the original estimate due to lower than expected consultant costs. The total project cost was US$217.73 million, about 30% more than the US$167 million originally estimated.

	Appraisal Estimate			Actual Costs		
	Local	Foreign	Total	Local	Foreign	Total
	- - -	(US$ million)	- -	- - -	(US$ million)	- -
Nakdong barrage	53.0	67.9	120.9	46.04	59.01	105.05
Land and compensation	27.0	--	27.0	37.56	--	37.56
Land development	--	--	--	22.27	9.54	31.81
Flood forecasting	--	--	--	0.64	5.72	6.36
Project management	13.7	5.4	19.1	22.70	8.95	31.65
Total Cost	93.7	73.3	167.0	129.21	83.22	212.43

B. Project Financing

Source	Planned		Actual	
	(US$ million)	%	(US$ million)	%
Bank loan	78.50	45	51.30	23.6
Domestic	93.52	55	166.41	76.4
Total	175.72	100	217.71	100.0

Table 6. Project Results

A. Direct Benefits (Present Value, Discounted at 10%)

Indicators	Appraisal Estimate	Closing Date Estimate	Estimate at Full Devt.
Savings in the alternative cost of transferring the water intake revenues from water sales	W 65,941 million	W 66,000 million	Same
Sale of reclaimed land	W 42,600 million	W 97,000 million	Same
Land appreciation due to project road	W 12,155 million	W 19,000 million	Same
Increased agricultural productivity	W 23,183 million	W 19,000 million	Same
Power sales	W 5,080 million	Not Computed	Same

B. Economic Impact

Economic Rate of Return	Appraisal Estimate	Actual
Base Case	24%	20%
10% Decrease in Benefits	22%	17%

C. Calculation of Actual Economic Rate of Return

ECONOMIC RATE OF RETURN — BILLION WON 1983 PRICES

YEAR	INVESTMENT Nakdong Barrage and Land Reclam. 1]	INVESTMENT Other 2]	OPERATION 3]	TOTAL EXPENSES	Incremental Water sold Million cu m 4]	TOTAL BENEFITS (Billion Won) Water Revenues 5]	Relocation Intakes 6]	Land Reclamation 7]	Bridge 8]	Agriculture 9]	Power 10]	TOTAL BENEFITS	NET BENEFITS Billion Won
1983	4.83			4.83		0.00		0.00				0.00	-4.83
1984	27.37			27.37		0.00		0.00				0.00	-27.37
1985	46.65			46.65		0.00		0.00				0.00	-46.65
1986	49.69			49.69		0.00	25.67	0.00				25.67	-24.02
1987	51.59		0.40	51.99		0.00	25.67	26.42				52.09	0.09
1988	6.62	2.10	0.50	9.22	342.3	1.83	13.50	39.54	9.43	-7.20	-	57.10	47.87
1989	2.85	2.10	0.50	5.45	388.5	2.08	13.50	56.22	9.43	-6.00	-	75.23	69.78
1990	0.00		0.50	0.50	437.5	2.35		37.93	1.30	-6.00	-	35.57	35.07
1991			0.50	0.50	489.7	2.62		28.71	1.35	3.80	-	36.49	35.99
1992			0.50	0.50	529.8	2.84			1.41	5.30	-	9.55	9.05
1993			0.50	0.50	571.8	3.06			1.46	6.80	-	11.33	10.83
1994			0.50	0.50	615.7	3.30			1.52	6.80	-	11.62	11.12
1995			0.50	0.50	630.7	3.38			1.58	6.80	-	11.76	11.26
1996			0.50	0.50	630.7	3.38			1.64	6.80	-	11.83	11.33
1997			0.50	0.50	630.7	3.38			1.71	6.80	-	11.89	11.39
1998			0.50	0.50	630.7	3.38			1.78	6.80	-	11.96	11.46
1999			0.50	0.50	630.7	3.38			1.85	6.80	-	12.03	11.53
2000			0.50	0.50	630.7	3.38			1.92	6.80	-	12.11	11.61
2001			0.50	0.50	630.7	3.38			2.00	6.80	-	12.18	11.68
2002			0.50	0.50	630.7	3.38			2.08	6.80	-	12.26	11.76
2003			0.50	0.50	630.7	3.38			2.16	6.80	-	12.35	11.85
2004			0.50	0.50	630.7	3.38			2.25	6.80	-	12.43	11.93
2004-2018			0.50	0.50	788.4	4.23			2.34	6.80	-	13.37	12.87
Present Value at 10%	133	2	3	139		18	48	97	19	19	0	62	19

THE ECONOMIC RATE OF RETURN (ERR) IS: 19.9%

SENSITIVITY ANALYSIS FOR ECONOMIC RATE OF RETURN	Economic Rate of Return
Benefits reduced by 10%	16.5%
Benefits Reduced by 20% for 10 Years	13.9%
Investment Cost Increased by 10%	16.9%
Investment Cost Increased by 10% and Benefits Reduced by 10%	16.0%

1] Excluding interest during construction and 5% taxes.
2] Complementary road investments to link with the barrage bridge.
3] KOWACO's staff and maintenance.
4] From detailed water demand analysis provided by KOWACO, but reduced by 20% assuming that relocation of Pusan and Ulsan intakes (otherwise needed) could have saved 5 cu m/second.
5] At the 1988 tariff of W 5.95 per cu meter (W 5.36 per cu meter in 1983 prices).
6] As estimated by consultants at appraisal. The real cost would likely be higher due to the need to provide compensation for houses and farms displaced by barrage construction. Even if intakes were relocated, a large part of the minimum flow would have to be used for flushing to prevent salinity in the Mulgeum agricultural area.
7] Based on actual sales and budgets for 1990-91.
8] Same as SAR, but increased 30%, a fraction of the increase in land scarcity.
9] Same as SAR. No changes in area or benefits.
10] Not carried out to simplify the analysis.

D. Financial Impact

	Projection for 1988	Actual, 1988 [4]	Revised Projection for 1991
ISWACO Water Division			
Raw water tariff (W/ton)	37.0	40.4	47.9
Operational revenues (W million)	68,340	63,465	118,000
Operational expenses (W million)	40,450	48,210	82,500
Depreciation (W million) rev.	11,220	8,213	14,500
Net income (W million)	16,400	3,937	13,100
Working ratio (%)	60	76	70
Rate of return (on rev. assets) (%)	5	3	5
Capital expenditures (W million)	58,150	76,635	135,000
% Debt service ratio	10.9	1.7	2.0
% Debt/(debt + equity)	18	2.5	13.0
ISWACO DAMS DIVISION			
Power rate (W/kWh)	27.5	37.3	44.0
Mun. and ind. rate (W/cu m)1	2.4	5.95	6.30
Operational revenues (W million)	77,855	52,873	101,300
Operational expenses (W million)	12,247	13,702	26,300
Depreciation (W million)	25,121	21,595	30,800
Net income (W million)	27,602	-12,997	14,300
% working ratio	16	25.9	26.0
% rate of return (revalued)	5	2.6	5.0
Capital expenditures	77,529	214,741	185,000
% capital expenditures to net fixed assets	9	31	20
Debt service ratio	1.8	0.6	1.9
Debt/(debt + equity)	18	37	23

[4] 1988 was one of the worst drought years in Korea in this century.

E. Studies

Study	Purpose	Status	Impact
Study of Intertidal Areas Requiring Protection	To determine zone in estuary to be made Natural Environment Preservation Area (NEPA) to preserve bird habitat.	Completed	NEPA (34.2 sq km) approved on December 31, 1988; part of the NEPA area converted to Natural Ecological System Preservation Area on March 1, 1989, giving maximum ecological protection under law.
Various environmental impact studies	To minimize unfavorable ecological impact from the barrage.	Completed	Eight monitoring points were established around the barrage, and a system for monitoring ecological and biological parameters was introduced to ensure environmental protection. More detailed operating rules were also established for the barrage to ensure acceptable water quality until completion of the Janglim interceptor.

Table 7. Status of Covenants

Covenant	Subject	Deadline for Compliance	Status
Loan Agreement			
3.02 (a) and side letter	Government to provide KOWACO with W 14 billion in 1984 and W 17 billion in 1985-86.		Satisfactory. KOWACO received W 35 billion by November 1984.
3.05 (b)	MOHA to maintain a separate account for its project components and submit to the Bank annual audit reports for the account.	By June 30 of each year.	Satisfactory. Due to the satisfactory audits submitted by Government and the low cost of this component, distributed between leak detection and computerization in 35 cities, no audit reports were needed.
4.02	Pusan City to carry out complementary water production/distribution and sewerage works.	December 31, 1987	Water distribution works completed ahead of schedule but Janglim interceptor sewer will not be completed until 1990 due to Pusan's financial constraints.
4.03 (a)	MOC to establish a Natural Environment Preservation Area in the Nakdong estuary.	June 30, 1985	Satisfactory. Achieved on December 31, 1988 due to resistance of Pusan City and lengthy approval process for the NEPA. A moratorium on construction froze development in the area even before approval of the NEPA.
4.03 (b)	OOE to establish a Natural Ecological System Preservation Area to protect the Nakdong estuary.	December 31, 1985	Maximum protection under Korean law given to the estuary area in February 1989. This was the first area given this protection.
Project Agreement			
2.02	KOWACO to use consultants for project supervision and environmental monitoring.	Continuously	Consultants worked satisfactorily throughout project period.
2.06	KOWACO to prepare an inspection and maintenance program for the Nakdong Barrage.	December 31, 1986	Satisfactory
4.02	KOWACO to submit to Bank annual audit reports.	Yearly	Satisfactory
4.03	KOWACO to revalue the fixed assets of its Water and Dams Divisions.	December 31, 1984	Satisfactory
4.04	KOWACO Water and Dams Divisions to earn a rate of return on revalued assets of 4% in 1984-85 and 5% thereafter.	Yearly	Rates of return were as follows: for the Water Division, 4.9% in 1985, 5.2% in 1986, 6.9% in 1987 and 2.8% in 1988, the fall-off due to a severe drought, large assets entering into operation and the take-over of an uneconomic system (Geum Gang); for the Dams Division, 2.5% in 1985, 4.0% in 1986, 9.0% in 1987 and 2.6% in 1988, again due to the drought.
4.05 (a)	KOWACO to maintain debt service ratio of less than 1.3.	Yearly	Greatly in excess of requirement, other than in 1988 for the Dams Division because of the drought.

4.06	KOWACO to provide updated 5-year financial projections.	Yearly by August 31	Satisfactory, using computer programs prepared by Bank staff.
4.07 (a)	KOWACO to establish a project and management monitoring system.	March 31, 1984	System established in August 1984 and reports produced periodically.
4.07 (b)	KOWACO to submit progress reports by August 31 and February 28 of each year.	Yearly	Satisfactory

Table 8. Use of Bank Resources

A. Staff Inputs

Stage of Project Cycle	Planned HQ	Planned Field	Revised HQ	Revised Field	Final HQ	Final Field
Through Appraisal	n.a.	n.a.	n.a.	n.a.	47.7	8.2
Appraisal through Board Approval	n.a.	n.a.	n.a.	n.a.	12.3	-
Board Approval -- Effectiveness	n.a.	n.a.	n.a.	n.a.	1.8	0.2
Supervision	n.a.	n.a.	n.a.	n.a.	59.1	9.0
TOTAL	n.a.	n.a.	n.a.	n.a.	120.9	17.4

B. Missions

Stage of Project Cycle	Month/ Year	Number of Persons	Days in Field	Specialization Represented[5]	Performance Rating Status[6]	Type of Problems[7]
Through Appraisal						
	03/82	2	1	FNA,EGR	-	-
	06/82	1	2	EGR	-	-
	10/82	2	3	EGR,FNA	-	-
(Identification)	12/82	1	10	FNA	-	-
(Preappraisal)	02/83	3	10	FNA,EGR,EGR	-	-
(Appraisal)	05/83	2	21	FNA,EGR		
To Effectiveness	11/83	2	1	FNA,EGR	1	-
Supervision						
1.	03/84	2	3	FNA,EGR	1	-
2.	11/84	2	5	FNA,EGR	1	-
3.	02/85	2	1	FNA,EGR	-	-
4.	11/85	2	3	FNA,EGR	2	ENV,FNA
5.	03/86	3	21	FNA,EGR,EGR	3	ENV,OPER
6.	11/86	2	2	FNA,EGR	1	-
7.	03/87	2	3	FNA,EGR	3	ENV,OPER
8.	08/87	1	1	FNA	-	-
9.	05/88	2	3	FNA,EGR	1	-
10.	10/88	1	1	FNA	2	ENV
11.	02/89	2	2	FNA,EGR	1	-
12.	06/89	1	1	FNA	1	-

[5] FNA = financial analayst; EGR = municipal engineer.

[6] Rating refers to overall project status; 1 = no significant problems, 2 = moderate problems, 3 = major problems but adequate attention is being given to them by implementing agency, and 4 = major problems which are not being adequately addressed.

[7] ENV = relating to project's environmental impact; FNA = relating to project's financing or financial impact; OPER = relating to operational problems of the barrage caused by delayed construction of interceptor sewer by Pusan City.